HOWARD = ELLERS (G.)
A proposed system of
Water = supply for the town of
Jefferson - Ill. - box 560

Jefferson Water Works.--1885.

Compliments of

G. HOWARD-ELLERS,

P. O. BOX 327. CHICAGO.

A Proposed System

OF

WATER SUPPLY

FOR THE

Town of JEFFERSON, Ills.

Adjoining the city of

CHICAGO.

A REPORT thereon

by

G. HOWARD-ELLERS,

Civil Engineer.

CHICAGO:
A. J. MADDEN, PRINTER.
1885.

CHICAGO, 1st October, 1885.

TO THE BOARD OF TRUSTEES

of the

TOWN OF JEFFERSON, ILLS.

GENTLEMEN:

On the 27th day of July of the current year, I received the following communication, which was handed me—in person—by the chairman of your Committee:

"CHICAGO, July 27th, 1885.

MR. G. HOWARD-ELLERS,

Civil Engineer, &c.,

MY DEAR SIR:

The undersigned, a committee appointed by the Trustees of the Town of Jefferson, at a meeting held in the Town Hall on Wednesday, the 22d inst., were then and there duly authorized and instructed to employ an engineer, whose duty it should be to prepare plans, specifications and estimates, and to examine and report upon what he may regard as the best and most economical system of furnishing the Town with a reliable and permanent supply of pure and wholesome water—hereby select and employ you as such engineer; and we request that you proceed—at your earliest convenience—to carry out the wishes of the Board of Trustees, as expressed in the resolution constituting and appointing this Committee. We are, &c., very respectfully yours,

(Signed) S. S. KIMBALL,
CARL KOCH,
WM. BARAGWANATH,
Committee."

I have—as requested by your Committee in the foregoing communication—made a personal examination of every part of your Town and its surrounding territory, carefully considering—while so

engaged—its present necessities and future possibilities; and I have likewise caused such additional instrumental surveys to be made, with results, which have enabled me to reach conclusions, made the basis of recommendations embodied herein. Your Committee, in their request that I will formulate and recommend a plan through which your Town can be permanently supplied with *pure* and *wholesome* water, tersely express the natural desire of all communities for an abundant supply, and for the unrestricted use of Nature's most essential health-giving and health-preserving element; because pure water, pure air, pure soil, pure nutritious food, personal cleanliness and plenty of sunlight are the sanitary essentials vital to the attainment, and to the preservation of vigorous health and long life, for without the first-named, existence becomes a burden and usefulness is at an end. The absolute necessity of practically pure water is of the first importance, because, as a distingnished sanitary authority tell us, deleterious impurities, when combined with water, act with marked rapidity on the human system, into which they speedily pass, by the sure process of venous absorption. In a practical sense water that is absolutely or chemically pure is never found in a state of nature. To be wholesome—to be entirely fit for domestic and commercial purposes—water should be uniformly cool, well aerated, inodorous, without appreciable color and tasteless, unless in the latter case we except a slight pungency due to the presence of carbonic acid or oxygen. It should be free from animal or vegetable organisms—either living or dead—and when used internally for drinking purposes, and in its natural state, it should neither propagate disease nor cause death. Sufficiently soft for all culinary purposes, it should, in like degree, readily unite with and rapidly dissolve soap and similar compounds, resulting in speedy and pleasant saponification when used in the laundry, or as a detergent in bath or lavatory. Its action should be neutral when brought into contact with lead; and when raised to the boiling point for culinary purposes, or evaporated into steam under pressure, it should neither become turbid nor deposit scale or incrustation. Finally it should be absolutely free from all urban impurities and from even a taint of sewage contamination. Having thus enumerated the essential requisites constituting *pure* and *wholesome* water, fitted by nature for domestic, manufacturing and commercial purposes, the question at once presents itself—*can such water, or water approximating the foregoing requirements, be*

found in this vicinity—can the source of supply be easily and economically reached—and, when reached, will it be found in sufficient abundance to meet your present demands, as well as the inevitable increase in the immediate future, for which ample provision must be made, and without which no plan that can be formulated or suggested would be either recommendatory or reliable. I unhesitatingly answer the foregoing affirmatively, aud in specifying Lake Michigan as the proper source from which to draw your water supply for all time, I have not failed to give due consideration to the question of deriving a supply of water for your Town, through the medium of Artesian wells, driven into the water-bearing strata which would—in all probability—be found at depths varying between twelve hundred and two thousand feet: and while not unmindful of the economy which might be claimed for the first cost of such a plan, growing out of improvements in the "driven well" system forming the subject of patents still in force and of conceded value, nevertheless, when we consider the character of the geological horizon in which water in sufficient abundance might be found, I am strongly inclined to be of the opinion it would occupy too high a position in the scale of hardness to render it suitable for domestic, manufacturing and commercial purposes. Hard waters are unfit for ordinary use in the kitchen and laundry, and are even more objectionable when used for the generation of steam under pressure in ordinary boiler practice; but authorities differ somewhat as to the pathological effects following the use of drinking water containing earthy salts in moderate proportions. Water is rendered *hard* by the presence therein of the carbonate and sulphate of lime, and the carbonate of magnesia, and experience would appear to indicate that waters obtained from Artesian wells are more likely to contain such and similar ingredients in objectionable quantities, than are waters derived from rivers and lakes. Of course, notable exceptions are not wanting, the geological formations into which the wells are driven—through which the rivers flow—and in which the lakes are situated—largely controlling the quality of the waters furnished by these respective sources now under consideration. It is not claimed that water obtained from either streams or lakes is always free from contaminating influences, or from impurities in some form, either in combination or in suspension—nevertheless, when it is remembered that all such aggregations of water are constantly absorbing oxygen during the perpetual aeration

to which they are subjected by the agitating action of the wind—by every breeze that disturbs their surface—and that the chemical oxidization which follows—ceaseless and searching—is largely supplemented by the consuming agencies of aquatic animals and plants, of fish and infusoria, it would certainly appear that your chances of obtaining a supply of *pure* and *wholesome* water from the grand reservoir of Lake Michigan, are unquestionably better than from Artesian wells driven into strata whose geological horizon is exclusively situated within the Calciferous and Magnesian formations. Having considered the *quality* of the water which it is reasonable to suppose any well driven into the water-bearing strata within the limits of your Town would be apt to furnish, it simply remains for me to say, that both the *quantity* discharged and the *durability* of the supply, might be seriously impaired by wells driven for such and similar purposes by parties possessing equal rights with yourselves, because the power—the legal right, to prosecute such work—*to seek for water and when found to use it*—is equally vested in all alike; it is, in fact, *general*, and *not exclusive*, and must, from the very nature of things, remain so forever. The one remaining source of supply to which your Town may resort with confidence—not only for the present but for all time—and the one which I unhesitatingly recommend for your adoption, is Lake Michigan. Swept by the winds from every point of the compass, storm tossed, and hence oxygenized and aerated by the atmospheric disturbances to which its surface is perpetually subjected—limpid, pure and soft—its waters rank among the *best* found anywhere, equaled by few, and for general domestic purposes surpassed by none. Such I take to be the normal condition of the waters of Lake Michigan, and such they will undoubtedly be found throughout their vast extent, with the possible exception of a limited area lying in front of this city, within the immediate influence of the putrid outflow from the Chicago river, and of the several main sewers of the urban system, whose outfall portals are located on the shore of the lake into which they discharge their dangerous contents. These grave violations of the fundamental teachings of sanitary science on the part of your south side neighbors, are efficiently supplemented, periodically, by the discharge from the twelve-feet conduit located beneath the surface of Fullerton Avenue, through which, aided by mechanical acceleration, the polluted contents of the North Branch of the Chicago river are discharged into the lake. Within this area,

whose extent is limited by local circumstances, and for variable periods during certain seasons of the year, I have no doubt the water of Lake Michigan is seriously deteriorated by sewage pollution. I know that this has—repeatedly and authoritatively—been denied, and that the accuracy of such denials has been, apparently, sustained and confirmed by the results of frequent analyses of the water made by chemists of conceded ability and acknowledged reputation. As opposed to this it is known that acute intestinal disorders prevail, to a greater or lesser extent, in this city; that the dissemination of diseases sometimes pronounced epidemic is not infrequent; and I also know, and, in fact, it may be accepted as a sanitary axiom, that such and similar disorders are common in all communities whose daily supply of drinking water is polluted by admixture with house sewage and human dejecta, with the discharge from the urinal and the cess-pool, the privy-vault and the slaughter-house. While the teachings of modern chemistry cannot safely be disregarded by engineer or layman, experience tells us that a knowledge of the pathological effects produced by the internal use of any water in its normal state, is of equal value with a similar knowledge of the analytical definition of its chemical constituents; because, the human system is a more sensible re-agent than any which the chemist can use in his laboratory determinations—and hence, in this regard at least, the dicta of vital statistics approach infallibility. But it is not with the sanitary short-comings of your neighbors that we are called upon to deal, except to the extent their resultant effects influence the location of the point in Lake Michigan at which the proposed water supply for your Town should be taken; besides, the day is not far distant when the pollution of the lake water in front of the city will cease forever, the large interests endangered, and the ever present menace to health and life, demanding an immediate application of the remedy whose technical nature is apparent, whose practical execution easy, and whose first cost within the limits of just and prudent economy. Having thus considered the character of the various sources of supply to which your town is practically limited, and having reached conclusions qualified and sanctioned by practical experience obtained during my incumbency as Chief Engineer of the water supply system of the Town of Hyde Park, in the years 1882 and 1883, and during my connection, in the same capacity, with the General Sewerage and Drainage System of the city of Chicago, in the years 1880, 1881

and 1882, it now remains to outline the plan which such experience suggests as the best—most durable—and hence, all things considered, the most economical for you to adopt, and which, followed by the necessary detailed estimates and appropriate specifications, will conclude the task your confidence has imposed on me. No design for obtaining a supply of water from Lake Michigan, is entirely safe or reliable, that does not contemplate and include the construction of a sub-aqueous conduit, executed in tunneled excavation and brick masonry, at a sufficient depth beneath the bed of the lake, and extended—lakeward—to a sufficient distance from the shore, to insure absolute freedom from the effects of shore erosion, or possible contamination from any source—from serious obstruction from ice packs during the winter, and which allows the location of the off-shore inlet in water of sufficient depth, to insure a supply whose temperature shall meet the requirements of practical uniformity the year round. Of the two plans for obtaining a supply of water from Lake Michigan, which are hereinafter outlined and recommended for your consideration, the sub-aqueous conduit is common to both. The first plan contemplates the location of the pumping station within the corporate limits of your Town, to which it is proposed to convey the water through an extension of the conduit from the land shaft in the lake shore, through the adjoining Town of Lake View, to the gate chamber within the grounds of the pumping station. In the second plan it is proposed to locate the pumping station on a site within the Town of Lake View, immediately on the lake shore, and contiguous to the land shaft therein, from which it is proposed to convey the water through a short brick conduit or cast iron pipe discharging directly into the pump well; the supply from the pumps reaching the the general system of distribution in your Town through a cast iron force main whose length would—practically—be equal to the conduit extension embodied in the plan previously outlined. Two points on the lake shore, whereon to locate and construct the important part of the water supply system herein contemplated, at once suggest themselves by reason of their general elegibility, and because of the easy and direct line which both offer, and on either of which your Town can be reached through the Town of Lake View. The first site suggested is at or near the foot of Montrose Boulevard in the immediate vicinity of its intersection with North Halsted Street; and the second site is at or near the foot of Belmont Avenue—both sites

being practically on the lake shore, from which these two broad avenues run directly west, through the Town of Lake View, to distant points within and beyond the Town of Jefferson, and both reach, in a straight and unbroken line, highly favorable locations for any part of your proposed work immediately within and directly west of your easterly Town line, and on or near one of the principal divisions of the Chicago and Northwestern Rail Road. In the selection of these two points from which it is proposed to obtain a supply of water for your Town, I have not been unmindful of the contiguity of the Belmont Avenue location to the lake area lying some distance south immediately in front of the city, whose periodical pollution from the combined action of the Chicago river and the Fullerton Avenue conduit I have already discussed at some length. I do not entertain a doubt but what the existence of these vile sources of pollution is limited, and their speedy disappearance as the result of measures now in contemplation and not difficult of execution, assured. The constant action of the *littoral* current, which, though gentle, is always *southerly* on the *west shore* of Lake Michigan when uninfluenced by high winds in an opposite direction, must not be lost sight of, while the chances of sewage contamination from the northward, due to any great increase in population in that direction, are exceedingly small, if indeed they will ever exist at all. *Within the central and higher northern latitudes, and in the absence of local circumstances of a controlling character, the general tendency of the movement of population is always in a southerly direction.* Recognizing all these facts, it is difficult for me to see wherein either of the proposed locations can be improved, so long as the limiting and controlling question of *cost* compels the construction of your proposed work on the *direct pressure* system of water supply. Notwithstanding this condition of things, I have not hesitated to so proportion the sub-aqueous conduit, as to render it capable of meeting every possible demand to which it may be subjected for—practically—an indefinite period; prominent among which will be a supply of water to your *neighbors* for various purposes, coupled with an extension of *house service* to them—direct—through your main system of distribution; the *income* from which, if prudently handled in a business-like way, will surely result in *cheap service to yourselves*, and to the rapid accumulation of a surplus sufficient to meet the interest on your water bonds—to retire the latter at maturity, and to provide for additional pumping machinery, which the

inevitable increase in population will surely make obligatory in the early future. Let it not be supposed, however, that in recommending for your adoption a system of water supply on the—so-called—*direct pressure plan*—that the latter plan has my unreserved assent as an engineer, or my unqualified endorsement as a prudent man; because, so long as iron will bend and steel will break, just so long is any system of water supply in absolute dependence thereon, constantly endangered by the suspended sword of disaster. As in your own case, instances are common where—*what we would like to do—must wait on what we find it possible to do with the limited means at our disposal.* Outside of this, the only drawback to either of the plans suggested, is the compulsory location of your pumping station in localities—where—sooner or later, it must of necessity become surrounded with dwelling houses, and other structures following the inevitable march of improvement, and hence, to that extent, will constantly be subjected to the grave danger of fire, always present where man lives and works, no matter how zealous the guard or how perfect its training and organization. If your corporation, instead of being a town with a resident population of only some fifteen or twenty thousand inhabitants—but undoubtedly containing within itself all the essential elements of an indefinite increase—*was a city*, with a permanent population of half a million or a million people, and with aggregated interests and accumulated wealth in proportion to its population and commanding position, then I should say adopt no plan that failed to satisfy every possible requirement of absolute safety and freedom from accident for all time: and, as a logical sequence to such recommendation I would also say, go to the elevated plateau, which, as I am informed, lies some thirty miles or so to the northward—whose eastern escarpment overlooks the broad expanse of Lake Michigan, and where, presuming my information to be correct, a sufficiently elevated area exists whereon to construct a system of storage reservoirs, large enough to hold a supply of water sufficient for all possible demands for a fixed period—say two to four months—erect the pumping station and plant on the lake shore—put in a subaqueous conduit fifteen or twenty feet in diameter, and *only* of sufficient length to permit the offshore inlet to be located in water deep enough to insure its absolute freedom from the effects of shore erosion, or temporary obstruction from floating ice packs—pump the water from the lake into the reservoirs, and then let gravity do the

rest of the work through a system of iron mains delivering the supply, under pressure, to the point where connection is made with the general system of urban distribution. Thus would be obtained a system of water supply whose condition would be one of absolute reliability at all times; secure from danger of sewage contamination by reason of its remote location, its continuity of supply would be assured, because the quantity of water in store would always be sufficient to meet the maximum requirements of any period, during which it would be possible to render the entire pumping outfit absolutely useless, as the result of any one of the many accidents to which steam plant is perpetually liable. *In the construction of any system of water supply for general domestic and commercial purposes, no ideas of a mistaken or false economy should be permitted to interfere with a prudent liberality of design.* That such a piece of work is not only intended to meet the wants of to-day, but is likewise expected to fulfill its mission for all future time, is a suggestive fact that should never be forgotten. On the question of what constitutes a proper daily allowance of water for all purposes, opinions differ about as widely as does the consumption of the water itself in different places. By many engineers an allowance of sixty gallons per capita per diem is regarded as ample, and I have no doubt it is could wastage be prevented and economy enforced, but, inasmuch as a liberal use of water appears to be essential to health, comfort and happiness, I am inclined to recommend as few restrictions on its use as an enlightened policy will sanction. Varying with localities and seasons, experience shows the daily consumption of water to depend upon some or all of the following uses to which it is hourly applied—

First. For *interior* consumption of a strictly domestic character in the kitchens, lavatories, bath rooms, water closets, urinals, laundries and elevators in dwelling houses, hotels, etc., and in boilers furnishing hot water or steam for heating or drying purposes therein, or for driving prime motors and steam pumps of the character generally used in hotels and the larger apartment houses, thirty (30) gallons per capita per diem.

Second. For *exterior* consumption of a similar character in stables, and for washing side walks, yards and the exterior of houses, and for sprinkling lawns and gardens, ten (10) gallons per capita per diem.

Third. For commercial, manufacturing and mechanical purposes, twenty (20) gallons per capita per diem.

Fourth. For public drinking fountains for "man and beast," for public urinals, and for fountains of an ornamental character and for similar purposes in public parks and grounds, and in public baths, and for washing and sprinkling streets and flushing sewers, fifteen (15) gallons per capita per diem.

Fifth. For the extinguishment of fires and for fire department uses generally, one (1) gallon per capita per diem.

Sixth. For *wastage*—both avoidable and what may be regarded as practically unavoidable, such as leakages in the main distributing systems, and in the lateral or house service systems; and in the colder seasons and localities, where the water in dwelling houses and other places is allowed to run to waste to prevent freezing, and the consequent destruction of the house service pipes and flooding of premises, etc., fifteen (15) gallons per capita per diem.

This shows a consumption of ninety-one gallons per head of population per day, and which, though excessive, is far from being overstated—because it is a matter of record that a consumption of one hundred gallons per capita per diem has been reached in some cities, and, in instances not rare, it has been and is being exceeded in a number of cases not difficult of absolute verification. Assuming the present population of your Town to be twenty thousand, and allowing a supply of one hundred gallons per capita per diem, will require a daily delivery of two million gallons, and this is the basis which I have used in all the estimates which are submitted herein, except in the proportions given the sub-aqueous conduit, and its landward extension, and in the case of the force main connecting the pumping plant with the distributing system throughout your Town.

In my report to the Trustees of Hyde Park which preceded the location of the water supply tunnel which I designed, and which was subsequently constructed during the years 1882 and 1883, beneath the bed of Lake Michigan at the foot of Sixty-Eighth Street, I recommended a conduit with a vertical diameter of six feet and three inches, and a horizontal diameter of six feet; and notwithstanding considerable opposition begotten in ignorance and born of parsimony, I persisted in the adoption of the dimensions which experience foretold would be the safest, and the work was accordingly executed in consonance with my wishes. At that time the daily consumption of water in Hyde Park was less than five million gallons per diem—as a matter of record it did not exceed sixty-five million gallons per

month, the maximum capacity of their pumping plant being equal to a delivery of six million gallons per day. In a subsequent report I suggested the advisability of providing for an increase of pumping capacity, and I named a period of five years within which such an addition to their pumping plant would be found obligatory. To-day the authorities of Hyde Park are inviting tenders for a pair of pumping engines capable of delivering *twelve million* gallons per diem. Should this rate of increase continue, the capacity of their subaqueous conduit will be reached within a period of twenty years, and perhaps even less. Seeing no good reason why I should anticipate a different result in your own case—all things considered—I have adopted the same proportions for the sub-aqueous conduit proposed in connection with your own work, firmly convinced it will be found the most advisable, as well as the most economical, especially when it is remembered that your ability to supply the wants of your neighbors can be made a source of revenue largely in excess of any outlay that may be required to maintain and operate your proposed works, to duplicate your pumping plant when required, and, finally to meet the interest on original expenditure for which timely provision is always necessary. For similar reasons I have adopted a diameter of five feet for the extension of the conduit from the shaft in the lake shore, to the gate chamber adjoining the pumping station, where the location of the latter is proposed within the corporate limits of your Town. In my judgment a length of 3,000 feet will be sufficient for the sub-aqueous portion of the proposed conduit, measured from the vertical shaft in the lake shore to the shaft in the offshore inlet; and I have given both shafts a finished diameter of eight feet on the accompanying tracing showing this portion of the proposed work, although I should be inclined to recommend that the diameter of the lake inlet shaft be made not less than ten feet when finally constructed; and, as a question of *first cost entirely*, although I cannot say it has my unqualified approbation, I have adopted the plan of a *submerged inlet in the lake*, in place of the more reliable—but unquestionably more costly form of protection suggested by existing structures somewhat modified and improved as the result of observation and experience. Recognizing the fact that the health and comfort of your people, and the saftey of the homes they occupy, are largely dependent on the strength and character of the pumping plant, the structural features of the engines and boilers which are proposed for

your use, are exclusively such as experience has shown to be among the most reliable and economical of their class and kind. The efficiency of the pumping service of any municipality largely underlies the health—the safety—the comfort and the prosperity of its inhabitants, and such efficiency undoubtedly depends—to a very considerable extent—upon the character and durability of the engines, and the freedom from accidents which can only be assured by intelligent design—by the strength and quality of the materials used, and by the mechanical execution of the work at the hands of competent and honest men. The pump plant proposed is of the "Duplex" type, and consists of two horizontal, direct acting, compound, high pressure condensing engines; each engine having two horizontal double-acting pumps, with plungers fourteen inches in diameter, and arranged side by side on the same frame; each pump being operated directly by a compound engine with steam-jacketed cylinders—the high pressure cylinder having a diameter of sixteen inches, and the low pressure cylinder a diameter of twenty-eight inches, the strokes of the engines and pumps being thirty inches. These engines are set in pairs—side by side—and each engine is so constructed as to be capable of working together, as a pair, with the duplex principle of valve movement, or, by disconnecting the duplex gearing, each engine can be operated as an independent pumping machine by itself. The combined capacity of this pumping plant is equal to a delivery of four million gallons of water per day of twenty-four hours, against an ordinary, or, what is called a *domestic* pressure, of sixty pounds per square inch, although they are capable of working against an extraordinary, or, as it is sometimes called, a *fire* pressure, of one hundred and fifty pounds per square inch. I do not regard the capacity proposed as at all excessive, your daily requirements, *now*, being, in my opinion, fully forty per centum of the total capacity of the proposed pumping outfit which I have herein outlined. These engines should be capable of giving a maximum duty equal to the elevation of seventy million pounds of water one foot high, with a consumption of one hundred pounds of good merchantable coal without any deduction therefrom for ashes, clinkers or waste, and with a maximum boiler pressure not exceeding ninety pounds to the square inch. I do not attach very much importance, however, to these so-called *special duty* trials, the only reliable and practical test of the efficiency of a pumping engine being—to my way of thinking—*its*

yearly record—showing what the machine does, day in and day out, and what it is capable of doing under all the varying conditions and demands of the public service. In the steam generating plant proposed, two systems only are considered—the Babcock and Wilcox water tube boiler—and the old fashioned but well approved, cylindrical return tubular boiler—both are the very best that can be devised—although I am strongly inclined to recommend the water tube type, alike on the score of ultimate safety, as of recognized efficiency and approved economy; both engines and boilers are explained and defined in the general specifications which I have prepared, and which form a part of this report. The station building designed to contain the engines and boilers, is a rectangular structure of brick, with stone and terra cotta trimmings, 52 feet front, 92 feet deep, and about 18 feet high to the eaves, and with a chimney stack in the rear, 84 feet high. Within the building is an engine room fifty feet square, and separated from it by a twelve inch wall, is a boiler room, fifty feet by forty feet. Space has been provided in both engine and boiler rooms for additions to both plants, which an increased demand for water will certainly render necessary at an early day. Parallel to the main structure on both sides, and distant therefrom some fifty feet, are the coal sheds, blacksmith and repair shop, and store room—extending from about the center of the building, rearward, some 130 feet. Connecting the boiler room with the coal sheds on each side is a narrow gauge track, extending through the boiler room, parallel with the fire fronts, and within easy handling distance of the furnace doors and ash pits. On the outer side of the coal sheds, extending to the rear of the enclosure, is a standard gauge track, making connection with a proposed siding on the line of the Chicago and Northwestern Rail Road, supposing the pumping station to be located within your Town as suggested in one of the plans herein submitted for your consideration. The pump well is rectangular on plan, about fifty feet long, twenty feet wide and twenty-five feet deep, into which the water is delivered to the suction pipes leading to the pumps, through a brick conduit five feet in diameter, and connecting the well with the gate chamber on the exterior of the building. The enclosed grounds surrounding the pumping station have a frontage of 300 feet and a depth of 350 feet, and this entire area should be enclosed on the sides and rear with a substantial fence, while that portion of the grounds situated in front and on the sides

of the main building, should be converted into a lawn, and the entire front neatly finished with a tasty but inexpensive parapet wall about two feet high, with steps from the side walk, and a broad graveled path leading to the main entrance to the engine room. Having thus outlined the various plans which past experience and a careful consideration of the situation would seem to indicate as best suited to meet your requirements, it simply remains for me to say, that, as a matter of course, much of the work herein recommended might be dispensed with. For instance, the sub-aqueous conduit or tunnel could be replaced with a precarious makeshift in the shape of an ordinary cast iron pipe laid on the bed of the lake, and prevented from wobbling around—generally and promiscuously—by piling; the substantial and durable pumping station could also be replaced with a frame shanty covering the engines and boilers, and with an overgrown stove pipe for a chimney stack; and finally an ordinary hole dug in the ground and lined with plank could be substituted for the capacious and substantial pump well, which the precepts of accepted hydraulic practice lead me to regard as both safe and essential; but having a natural repugnance to slip shod work simply because it is cheap and will stand up or hold together for a year or two, I have not considered it necessary to submit an estimate for a class of work, whose execution would be indictable, and whose existence a crime. In the selection of materials to be used in the prosecution of your proposed work, none but the best should be recognized—because the best is always the cheapest—poor materials resulting in poor work, and poor work is sure to be followed by waste of time and money and general demoralization. In your distribution system cast iron pipe of approved make only should be given a place, and it should be subjected to practical inspection by an experienced expert, and not by a political slouch, whose only recommendation is the quantity of bad whisky he can carry or the number of votes he can influence. All water pipe should be thoroughly coated with the coal tar preparation formulated by Angus Smith, and should afterwards be subjected to a hydrostatic pressure of not less than 300 pounds per square inch. No pipe with a less diameter than six (6) inches should be used anywhere—it is, in fact—the *minimum size that should be adopted* for *branch mains* in any well designed system of water supply. *Large pipes discharge more in proportion to their areas than smaller ones, while the first cost is far from increasing with the same rapidity as*

does the discharging capacity. In the selection of water gates or stop valves no difficulty need be experienced, the "Chapman," "Ludlow" and "Eddy," leaving nothing to be desired in the way of perfection of design, standard materials and high class workmanship; while in the selection of a fire hydrant, I unhesitatingly recommend the double valve hydrant of Mr. Mathews of Philadelphia, although the Chapman and the Ludlow people make hydrants that are standard of their class and kind. The strength and stability as well as the lasting qualities of brick and stone masonry are largely dependent on the character and quality of the hydraulic cement used in producing the mortar in which all such work is imbedded, and in no department of engineering or constructive art, does masonry of this character occupy so important and responsible a position, as it does in hydraulic work such as we are herein considering—hence—I recommend the cement manufactured near Utica, in La Salle county in this State, and known on the market as the "James Clark" and "Black Ball" brands, for *exclusive* use in your proposed work. I have used this make of cement in the construction of over 102 miles of sewers in the city of Chicago, and in the water supply tunnel beneath Lake Michigan at the foot of 68th street, and it has never failed to meet all the requirements of my specifications, both for standard excellence, unequalled uniformity and honest and careful manufacture.

In the following estimates, I have used the cost of labor and materials current in the market at the present time—with such additions for possible increase as I have thought both safe and probable. The work estimated for will all be found explained and defined in detail in the various specifications in the Appendix hereto, except in two or three instances where the accompanying working tracings are themselves of a sufficiently explanatory character for all practical purposes.

Estimate No. 1. Showing the cost of the proposed conduit beneath the bed of the lake, with the land shaft on the lake shore, and the shaft in the lake inlet—complete—ready for use.

70	feet of vertical shaft on lake shore—8 feet finished diameter, at $56.57 per vertical foot... ....$	3,959.90
3000	feet tunneled conduit, at $20.31 per linear foot...	60,930.00
52	feet of vertical shaft in lake inlet—8 feet finished diameter, including iron cap and grating and all temporary works, at $326.28 per vertical foot..	16,966.56

1 Resident Engineer .... 1 Rodman and Assistant Inspector .... 1 Inspector on Underground Construction ..... 1 " of Materials at pit mouth .... 1 " " Mortar " " "	6,200.00
	$88,056.46.

The inspection force is—practically—only on duty during the "masons' shift," which accounts for its limited number.

Estimate No. 2. Showing the cost of the plan wherein it is proposed to locate the Pumping Station on Montrose Boulevard, west of its intersection with Western Avenue.

11,440	feet of brick conduit—5 feet diameter—extending from the land shaft in the lake shore, to the "gate chamber" within the grounds of the Pumping Station—at $9.39 per linear foot—in place—ready for use		107,421.60
2.5	Acres of land, at $1,200 per acre		3,000.00
1	Gate chamber, 40 feet deep, 8 feet diameter, including "gate house" and machinery—and conduit—5 feet diameter—leading into the pump well.		3,751.60
1	Main building including pump well and chimney stack—platform scale set in pit, and about 300 feet of 24 inch gauge track, connecting the boiler room with the coal sheds, etc		21,169.89
2	Pumping Engines—in place—ready for use	$17,000.00	
3	Babcock and Wilcox water tube boilers set in a single battery, etc., with all connections	6,100.00	23,100.00
2 1 1	Coal sheds, Repair shop, Store room, — Included in two separate structures, each 130 feet long, 30 feet wide and 18 feet high		2,675.28
	Fencing, surfacing and ornamenting grounds, etc.		1,000.00
	Engineering, Superintendence, Inspection, etc.		4,400.00
	Cost of Plan No. 1		$166,518.37

If the ordinary return tubular boiler is substituted for the water

tube type, then that item will appear in the foregoing estimate as follows, viz:

3	Steel, cylindrical, return tubular boilers, with all connections, etc.		$4,299.00

This shows a difference in first cost of $1,801 in favor of the latter style of boiler, notwithstanding which, I am convinced the water tube boiler will be found the most economical in the lapse of time, as it undoubtedly is the safest, most durable, and, all things considered, one of the most satisfactory steam generators used in the current practice of the day.

Estimate No. 3. Showing the cost of the plan wherein it is proposed to locate the Pumping Station on the lake shore, at or near the foot of Montrose Boulevard.

2.5	Acres of land at $3,500 per acre		$8,750.00
300	feet of brick conduit—five feet diameter—connecting the land shaft in the lake shore with the pump well at $9.39 per linear foot		2,817.00
1	Main building, including pump well and chimney stack, platform scale set in pit, and track, connecting boiler room with coal sheds, etc.		21,169.89
2	Pumping Engines in place—ready for use	$17,000.00	
3	Babcock and Wilcox water tube boilers, set in a single battery, etc., with all connections	6,100.00	23,100.00
2 1 1	Coal Sheds, Repair Shop, Store room, } Included in two separate structures, each 130 feet long, 30 feet wide and 18 feet high		2,675.28
11,440	feet cast iron force main, 30 inches diameter, in place, ready for use, at $5.77 per linear foot		66,008.80
	Fencing, surfacing and ornamenting grounds, etc.		1,000.00
	Engineering, Superintendence, Inspection, etc.		4,400.00
	Cost of Plan No. 2		$129,920.97

A deduction from the foregoing of $1,801 must be made, if the ordinary return tubular boiler is substituted for the water tube boiler

of Babcock and Wilcox as previously explained in the foot note to Estimate No. 2.

Estimate No. 4. Showing the cost of the plan wherein it is proposed to locate the Pumping Station at some point immediately west of the intersection of Belmont Avenue with Western Avenue.

13,640	feet of brick conduit, 6 feet diameter, extending from the land shaft in the lake shore at the foot of Belmont Avenue to the gate chamber within the grounds of the pumping station at $11.07 per linear foot—complete		$150,994.80
2.5	Acres of land at $1,600 per acre		4,000.00
1	Gate chamber, 40 feet deep, 8 feet diameter, including "gate house" and machinery—and conduit—6 feet diameter—leading into the pump well		4,234.92
1	Main building, including pump well and chimney stack, platform scale set in pit, and about 300 feet of 24 inch gauge track connecting the boiler room with the coal sheds, etc.		21,169.89
2	Pumping Engines, in place, ready for use	$17,000.00	
3	Babcock and Wilcox water tube boilers, set in single battery, etc., with all connections	6,100.00	23,100.00
2 1 1	Coal Sheds, Repair Shop, Store room, — Included in two separate structures, each 130 feet long, 30 feet wide and 18 feet high		2,675.28
	Fencing, surfacing and ornamenting grounds, etc.		1,000.00
	Engineering, Superintendence, Inspection, etc.		4,400.00
	Cost of Plan No. 3		$211,574.89

As in the case of the previous estimates, the sum of $1,801 will have to be deducted from the foregoing amount, should the return tubular boiler be substituted for the Babcock & Wilcox water tube steam generator.

Estimate No. 5. Showing the cost of the plan wherein it is proposed to locate the Pumping Station on the lake shore, at or near the foot of Belmont Avenue.

2.5	Acres of land at $10,250 per acre..............		$25,625.00
300	feet of brick conduit, 6 feet diameter, connecting the land shaft in the lake shore with the pump well, at $11.07 per linear foot..................		3,321.00
1	Main building, including pump well and chimney stack, platform scale set in pit, and 24 inch gauge track connecting boiler room with coal sheds, etc.		21,169.89
2	Pumping Engines, in place, ready for use.............................	$17,000.00	
3	Babcock & Wilcox water tube boilers, set in single battery, etc., with all necessary connections..........	6,100.00	23,100.00
2 1 1	Coal Sheds, Repair Shop, Store room, } Included in two separate structures, 130 feet long, 30 feet wide and 18 feet high.............		2,675.28
13,640	feet cast iron force main, 30 inches diameter, in place, ready for use, at $5.77 per linear foot....		78,702.80
	Fencing, surfacing and ornamenting grounds, etc.		1,000.00
	Engineering, Superintendence, Inspection, etc.		4,400.00
	Cost of Plan No. 4..........................		$159,993.97

As previously explained the sum of $1,801 will have to be deducted from the foregoing amount, should the style of boiler be changed to the return tubular type.

Deductions from the Foregoing Estimates.

Plan A.

Cost of taking four million gallons of water per diem, from a point in Lake Michigan, three thousand feet in a general easterly direction from the foot of Montrose Boulevard in the Town of Lake View; and *delivering the same* to the Pumping Station, located at a point west of the intersection of Montrose Boulevard with Western Avenue, in the Town of Jefferson,

fourteen thousand four hundred and forty feet from the *inlet in the lake through which the water is taken.*

Cost of the sub-aqueous conduit—complete—as per Estimate No. 1	$88,056.46
Cost of the landward extension of the conduit and of the Pumping Station, complete, as per Estimate No. 2	166,518.37
Cost of Plan A—complete.	$254,574.83

Plan B.

Cost of taking four million gallons of water per diem from a point in Lake Michigan, three thousand feet offshore in an easterly direction from the Pumping Station, located at the foot of Montrose Boulevard, in the Town of Lake View; and delivering the same through an iron force main, 30 inches diameter, to a point in the Town of Jefferson, west of Western Avenue on Montrose Boulevard, where connection with the general system of distribution will be effected.

Length of water supply tunnel 3,000 feet.

" " cast iron force main 11,440 "

Cost of sub-aqueous conduit as per Estimate No. 1.	$88,056.46
Cost of Pumping Station and force main, complete, as per Estimate No. 3	129.920.97
Cost of Plan B., complete	$217,977.43

Plan C.

Cost of taking four million gallons of water per diem from a point in Lake Michigan, three thousand feet east from the foot of Belmont Avenue, in the Town of Lake View; and delivering the same to the Pumping Station, located on Belmont Avenue, west of its intersection with Western Avenue, in the

Town of Jefferson, 16,640 feet from the inlet in the lake through which the water is taken.

Cost of the sub-aqueous conduit, complete, as per Estimate No. 1	$88,056.46
Cost of the landward extension of the conduit, and of the Pumping Station, complete, as per Estimate No. 4	211,574.89
Cost of Plan C., complete	$299,631.35

Plan D.

Cost of taking four million gallons of water per diem from a point in Lake Michigan, three thousand feet east from the Pumping Station located at the foot of Belmont Avenue, in the Town of Lake View; and delivering the same through an iron force main, 30 inches diameter, to a point in the Town of Jefferson, west of the intersection of Belmont Avenue with Western Avenue, where connection with the general system of distribution will be effected.

Length of water supply tunnel 3,000 feet.
" " cast iron force main 13,640 "

Cost of the sub-aqueous conduit or water supply tunnel—complete—as per Estimate No. 1	$88,056.46
Cost of Pumping Station and force main—complete—as per Estimate No. 5	159,993.97
Cost of Plan D., complete....	$248,050.43

Having considered the sources of supply within your reach—the character and quality of the water they furnish—and the cost of obtaining the same in sufficient volume, and delivering it at points within

your Town ready for attachment to any system of distribution your wants may devise, or your people and taxpayers ask for and are willing to pay for, it simply remains for me to conclude, with such recommendations as a careful study of the subject warrants, and which past experience sanctions.

First. I recommend that the supply of water for your Town be taken from Lake Michigan, through a brick conduit constructed beneath the bed of the lake, whose diameter shall not be less than six (6) feet--and that the inlet into this conduit be located at a point in the lake fully three thousand feet east of the shore line in the Town of Lake View.

Second. I recommend that the Pumping Station be located within the corporate limits of your Town, and that the water be conveyed to it from the land shaft in the lake shore, through a brick conduit, whose diameter shall not be less than five feet.

Third. The location of your proposed Pumping Works should be at some central point as between your North and South lines, but as near as possible to your eastern Town line—and hence—I recommend the adoption of Plan A. which locates the Pumping Station on Montrose Boulevard immediately west of its intersection with Western Avenue—for the following reasons:

a. Because of the two plans which come within the purview of my second recommendation, Plan A. costs the least to construct—and when constructed, will be the most economical to maintain and operate.

b. Because the location is the best, and will be the cheapest, from which to distribute the water in all directions throughout your own and adjacent Towns—North, South and West —North West and South West.

c. Because--partly in one case--and wholly in others, this location is—all things considered—the best from which and through which a supply of water can be conveyed to such of your neighbors as may want it (and they all do or will), and hence, the charges for such being irrespective of the location of your proposed works, the revenue derived will bear a much larger proportion to the first cost of Plan A-- then it will to that of Plan C.

Fourth. As regards your system of distribution, I recommend the use of cast iron pipes exclusively, of the following proportions

and weights—and when laid in the trenches, their tops should, in every case, be five feet beneath the surface of the roadways, and each joint should contain the quantity of gasket yarn and lead specified in the table below:

Inside diameter in inches.	Thickness of shell in inches.	Weight per linear foot in lbs.	Weight per length of 12 ft. 4 in. in lbs.	Weight of gasket yarn per joint.	Weight of lead per joint.
4	½	24	280	2½ oz.	6 lbs.
6	½	34	404	3 "	9 "
8	⅝	56	669	4 "	12 "
10	⅝	69	824	5 "	15 "
12	¾	99	1187	6 "	18 "
14	¾	115	1373	7 "	21 "
16	¾	130	1559	8 "	24 "
20	⅞	189	2267	10 "	30 "
24	1	259	3102	12 "	36 "
30	1⅛	361	4346	1 lb.	45 "

All pipes should be thoroughly coated with coal tar varnish as formulated by Angus Smith, and should afterwards be subjected to a hydrostatic pressure of not less than 300 lbs. per square inch. Fire hydrants should be placed at all street intersections, and whenever blocks exceed a length of 400 feet—a hydrant should also be placed in the centers of all such long blocks. No hydrant should be used that is not provided with double valves and movable frost cases, or whose stand pipes are less than four inches diameter; and the connections between all hydrants and street mains should always be made with pipes having the same diameters as the stand pipes of the hydrants they supply. No pipe should be used for street mains whose diameter is less than six inches—all smaller sizes being limited to hydrant connections or other species of service requiring larger quantities of water than the ordinary lead service pipe is capable of conveying.

Of the eleven sheets of tracings accompanying this Report—

No. 1—Is a Map of the Towns of Jefferson and Lake View, drawn to a scale of six inches to one mile.

No. 2—Is a Plan of the site of the Pumping Station.

No. 3—Is a side Elevation of the Pumping Station and Chimney Stack.

No. 4—Is a front Elevation of the Pumping Station.

No. 5—Is a rear Elevation of the Pumping Station and an entire elevation of the Chimney Stack.

No. 6—Is a longitudinal Section of the building, chimney stack and connecting flue, and a vertical cross section of the pump well.

No. 7—Is a plan of the Pumping Station.

No. 8—Is a top view—a side elevation and an end elevation of the pumping engines.

No. 9—Is a vertical longitudinal section of the pumping engines.

No. 10—Is a vertical section of the sub-aqueous conduit—of the land shaft—and of the conduit extension.

No. 11—Is a vertical section of the sub-aqueous conduit, and of the inlet shaft in the lake.

All the work embodied in the foregoing is explained in the Report or in the Appendix.

In the foregoing Report I have endeavored—imperfectly I admit—to meet your wishes as expressed to me in your communication of the 27th day of July ultimo, and it has been my aim to do so in a concise and practical manner expressed in plain English, but in so doing, I have not considered it necessary to write a treatise on the subject of water generally—to explain or to illustrate the important functions it discharges in Nature—the proportions contained in the human body—the extent to which it commingles with the solid materials out of which our World is formed, or to explain how the salt waters of the ocean by atmospheric influences and natural processes become the fresh waters of the land on which we live and work. Should there be any among your number desirous of refreshing their memory on this particular branch of elementary science, to all such would I say, read the interesting work from the French of Gaston Tissandier, entitled the "Wonders of Water," or the highly instructive lecture on the same subject, delivered by Prof. Chandler before the American Institute, a few years ago.

Every judicious improvement in the establishment of Public Works, increases the value of land, and augments the general wealth.

In conclusion I desire to record my obligations to my friend Mr. A. W. Wright, Chief Engineer of the N. C. C. R. R. Co., for valuable topographical data kindly furnished, and for many courtesies extended; and to my principal Assistant, Mr. J. S. Moloney, C. E., Associate Member of the Institution of Civil Engineers, for cordial and valuable co-operation at all times.

G. HOWARD-ELLERS,
Civil Engineer.

Chicago, 27th October, 1885.

APPENDIX.

JEFFERSON WATER WORKS, 1885.

SPECIFICATIONS,

describing and defining the manner in which it is proposed to construct a sub-aqueous conduit, for the purpose of furnishing a reliable supply of water to the Town of Jefferson, Illinios, adjoining the city of Chicago.

GENERAL DESCRIPTION AND LOCATION.

The work which it is proposed to execute in accordance with these specifications, will embrace the construction of a sub-aqueous conduit or water supply tunnel, extending in a general easterly direction beneath the bed of Lake Michigan, for a distance of .... feet from a vertical shaft to be located on the west shore of the lake at the foot of .... , to a similar shaft to be located at the easterly end of the proposed conduit, forming the inlet through which the water will reach and flow through the tunnel. Both land and lake shafts to be sunk to a depth of .... feet below the general datum plane to which all levels and vertical measurements will be referred. In general terms it may be said the entire work will be circular in section, the finished dimensions being—for the shaft in the lake shore—a diameter of eight (8) feet; for the inlet shaft in the lake a diameter of .... feet, and for the tunneled conduit a horizontal diameter or minor axis of six (6) feet, and a vertical diameter or major axis of six (6) feet and three (3) inches; to be executed throughout in first class brick masonry, carefully laid up in hydraulic cement mortar, and *in every respect* to be constructed and finished in a thorough and workmanlike manner, and in *absolute compliance* with the plans furnished by the Chief Engineer, duly certified by his official signature, and such instructions as he shall issue during the progress of the work—in person—or through his properly constituted representatives.

GRADES.

The tunneled conduit, extending eastwardly beneath the bed of the lake, *shall* be constructed with an inclination from the inlet shaft in the lake to the shaft in the lake shore—or—on a grade, which descends, shoreward at the rate of one tenth (0.1) of a foot per one hundred (100) feet, corresponding to a grade of five feet and twenty-eight (5.28) hundredths of a foot per mile.

EXCAVATION.

The excavation *shall* be commenced and prosecuted accurately upon the lines and levels given daily by the Resident Engineer; and the tools and appliances *shall* be of such a character as to render reasonably certain the accuracy and progress of the work in hand—and—when being driven through the formations which the borings show to probably exist along the entire line, or in the immediate vicinity of the proposed tunnel—the perimeter of the excavated section *shall* be carefully trimmed up, so as to conform closely—in shape and dimensions—with the exterior of the masonry when in place: As an illustration of which, it may be accepted as a guiding rule, that where the character of the surrounding material is favorable, the finished diameter of the excavated section ought not to exceed the exterior of the masonry more than two (2) inches at any point. In all other respects, the dimensions and shape of the excavation *shall* be such as to guarantee the absolute safety of the work while progressing, and its stability and standard character when finished. All surplus material removed from out the shaft and tunnel during the prosecution of the work from the shore end, *shall* be hauled to, and deposited at, such points as the Chief Engineer may direct—the average haul on which, *shall* not—however—exceed a distance of one thousand (1,000) feet from the mouth of the shaft.

Wherever rock is encountered, the "heading" *shall* be driven, and the full section of the tunnel excavated with such tools and appliances, and with such explosive compounds and weight of charges, as shall meet the approval of the Chief Engineer—and all inequalities in the perimeter of such rock work *shall* be filled, and worked up to the proper line and shape with concrete or stiff mortar, made in such proportions and otherwise used in such manner as appears elsewhere defined and directed herein.

SHAFT IN THE LAKE SHORE.

The work to be done here will consist in excavating and sinking the shaft to a depth of .... feet below the general datum plane. The brick masonry, with which the shaft *shall* be lined, following the excavation at a proper interval and with workmanlike regularity. The bottom of the shaft *shall* be paved with four (4) courses of brick masonry laid upon and surrounded by a footing or foundation of concrete five (5) feet thick, and when finished, the bottom *shall* be hemi-spherical, the center formed with a circular stone, accurately dressed to a diameter of two (2) feet, with a thickness of eighteen (18) inches, and with bed and top surface parallel. The vertical walls *shall* be footed upon this hemi-spherical bottom, and they *shall* be composed of four (4) rings of brick work to a height of forty (40) feet above the footing course, from which point to the surface of the ground the thickness of the walls *shall* be reduced to three (3) rings of brick work. The junctions between the walls of the main tunnel and of the landward extensions, and the walls of the shaft, *shall* be carefully made by experienced and competent mechanics, in the best and most workman like manner; and the top *shall* be finished with an hemi-spherical dome, the three (3) rings of brick work composing the walls being carried up and abutting on a cast iron circular curb or frame, leaving an opening in the center of the dome, three

(3) feet in diameter, which *shall* be closed with an iron cover cross-ribbed on its under surface. A wrought iron ladder, with sides three (3) inches broad and half (0.5) an inch thick, placed eighteen (18) inches apart, and with inch square rounds one foot apart centers vertically, *shall* be placed in the shaft in such position and manner as the Chief Engineer shall direct.

TUNNEL.

The elevation of the grade line of the tunnel where it joins the shaft *shall* be .... feet below the datum plane, at which point, and for a distance of twenty (20) feet eastwardly from the face of the shaft the walls shall consist of four (4) rings of brick masonry, and, for a further distance of twenty (20) feet of three (3) rings, from which latter point to the easterly terminus at the inlet shaft in the lake, the walls *shall* consist of two (2) rings, except at such points where, in the judgment of the Chief Engineer, the safety and durability of the tunnel may require an additional ring to insure absolute stability. The inverts *shall* be accurately trimmed out and worked into proper form with standard templets, the surface covered with a thick coating of mortar into which the bricks forming the exterior ring *shall* be imbedded at one operation—laid fair and true by line—generally as stretchers, and always breaking joints with the bricks in the adjoining courses. The arch *shall* be laid up on strong centers in a similar manner, and the centers kept in place until the mortar has taken a permanent set. All cavities around or in the rear of the brick-work *shall* be thoroughly filled with stiff mortar, or with concrete, or with brick masonry, as the Chief Engineer shall direct. The thickness of all mortar joints, as well between the bricks as between the rings, *shall* be half (½) inch, and they *shall* be struck and finished smooth and uniform every where, and all surplus mortar adhering to the face of the brick-work *shall* be removed so that the finished masonry *shall* be left in a clean and workmanlike condition throughout.

LAKE INLET SHAFT.

The character of the temporary structure within which the permanent work shall be prosecuted, will be optional with the contractors, who, as a matter of course, will be held responsible by the terms of their contract for final and successful results in accordance with the requirements of these specifications. Similarly, any practical system which the contractors may originate or adopt to enable them to successfully prosecute the work in hand, will not be interfered with, so long as the work itself is executed in a satisfactory manner as specified herein, and with commendable or reasonable rapidity, but its practical and vigorous prosecution during the months of June, July and August will be insisted upon, and to that extent *shall* be regarded as absolutely obligatory. The permanent work to be done at this point will consist in excavating and sinking the shaft to a depth of .... feet below the general datum plane, and an extension of the tunnel proper to a distance of about thirty (30) feet beyond the opposite side of the shaft, which latter extension *shall* be permanently closed with a bulkhead of solid brick masonry, one (1) foot beyond the eastern portal, and specifically constructed and finished as shown on exhibited plans officially at-

tested by the signature of the Chief Engineer. The shaft *shall* have a finished diameter of..........................feet, and the walls *shall* be composed of four (4) rings of brick masonry, footed on a hemispherical bottom, imbedded in a solid foundation of concrete precisely as indicated and specified in the case of the land shaft. The walls *shall* be finished at a point about three (3) feet *above* the *bed* of the lake, and capped with a cast iron curb or annular casing, carrying a wrought iron grated covering as shown on exhibited plans. The tentative character of this portion of the work is fully recognized, and hence, should it be deemed advisable to abandon the use of brick masonry in the vertical walls of the shaft only, for the purpose of attaining increased celerity, safety and economy, sectional cast iron cylinders, two (2) inches thick, with faced joints and interior flanges may be substituted, in accordance with plans to be exhibited and attested by the signature of the Chief Engineer.

All excavated material, and all debris *shall* be placed on a scow and *shall* not be dumped in the lake at any point within a radius of one thousand (1,000) feet from the inlet shaft; and when the latter is finished, all temporary structures *shall* be carefully and promptly removed, and the bed of the lake surrounding the;inlet left in the original condition which existed prior to the inauguration of the work.

MASONRY.

The character and quality of the bricks that *shall* be used in the masonry throughout are hereinafter specified. Prior to being placed in the car for transportation into the work, all bricks *shall* be wet to the point of absolute saturation with clean water—by immersion entire. In the work—they *shall* generally be laid as stretchers—fair and true to line, and so placed as to break joints—mid-length—with all bricks in adjacent courses. In the mortar beds—they *shall* be pressed into their proper positions by one operation for each brick, the object being to flush out all surplus mortar, thereby allowing the mortar joints to remain perfectly filled, and the bricks to be entirely imbedded, with joints on all sides which *shall* not exceed half ($\frac{1}{2}$) an inch in thickness,—*as a rule*—that *shall* be standard for the work throughout. The *un*workmanlike practice of "slushing" or working the mortar into the joints after the bricks are in place, is *absolutely prohibited.* As the brick work progresses, it *shall not* be racked back in courses, but at all points where joints are to be made, its temporary ends *shall* be left "toothed," for the purpose of facilitating the continuity and allignment.

BRICKS.

For use in this work the harder and denser varieties *shall* be given the preference. They *shall* be of the best quality, clear ringing, sound and smooth; burned hard and uniformly throughout, and free from lime pebbles and other stones; regular in shape and of standard dimensions. They *shall* be subjected to thorough inspection, when all bricks failing to meet the requirements of these specifications, and all bats, *shall* be culled out and placed in a pile by themselves, and their further use limited to concrete, or as filling in cavities, should such be encountered in the prosecution of the work.

CEMENT.

The hydraulic cement which *shall* be used—exclusively—in this work, is that manufactured at and near Utica, La Salle County, Illinois, and known in the market as the "James Clark" and "Black Ball" brands. It *shall* be fresh made and ground to such a degree of fineness that eighty (80) per cent. of the powder shall pass through a sieve having thirty-six hundred (3600) meshes to the square inch. If tested for setting qualities and for strength, promiscuous samples *shall* be mixed, neat, with clean water, and moulded into test pieces, which latter *shall* be allowed to stand—undisturbed—for six (6) hours in air, and then be immersed in water for forty-eight (48) hours, at the expiration of which period they *shall* be placed in the testing machine and subjected to a tensile strain of fifty (50) pounds to the square inch, failure to sustain which *shall* be regarded as a sufficient reason for instituting a thorough series of experimental tests, upon the average results of which *shall* depend the acceptance or rejection of the entire lot from which the samples were taken.

SAND.

All sand used *shall* be free from loam, clean, sharp, silicious, and as reasonably coarse as can be obtained in this locality—and—if deemed necessary by the Chief Engineer, it *shall* be screened and washed.

MORTAR—GROUT—CONCRETE.

All mortar *shall* be composed of equal volumes of cement powder and sand—"one to one"—by measure; thoroughly mixed in a dry state, and then brought to proper consistency with clean water, and *always* fresh made for the work in hand: It *shall be used immediately after being mixed*, and not allowed to remain on the *mortar boards* until it has *set*, and then be broken down, remixed or "retempered," so called.

Grout—if used at all—*shall* be composed of neat cement powder and clean water, mixed to such consistency with an excess of water, as *shall* enable it to thoroughly permeate and reach the most distant parts of the work wherein its use *shall* be found obligatory.

Concrete—*shall* be composed of *one* part cement powder, *two* parts sand, and *three* parts crushed stone, broken bricks or quarry chips, whose dimensions *shall* not exceed *one* inch and a *half* in any direction. All the foregoing proportions of cement powder, sand and stone, *shall* be ascertained and used by measure—the mortar being first made as hereinbefore specified—the stone, previously cleansed and sprinkled—then added—the mass thoroughly incorporated, and then immediately deposited in place in layers *not over* six (6) inches deep or thick at a time, and *tamped* until the water of admixture is flushed to the surface.

VENTILATION—ILLUMINATION.

During the prosecution of the work, some approved method of ventilation *shall* be adopted at the start, and kept in constant use. This may be effected by forcing pure air into the tunnel, and delivering same at the face of the work, thereby

creating an outward current through the heading and finished tunnel into the shaft, or, *vice versa*, by withdrawing the vitiated air at the face of the work, and the consequent creation of an inward current of pure air from the exterior, through tunnel and heading, from shaft to face. Either system may be used—the *prompt adoption of one shall be obligatory.* For this part of the work the Sturtevant Fan or the "Murphy Ventilator" should be given the preference, the latter machine being especially adapted to work of this character from the ease and rapidity with which it can be used either as an Exhauster or a Blower, at the will of the operator. The same may be said of some system of illumination other than by lanterns and the ordinary miner's lamp, and hence the adoption and use of the electric light *shall be obligatory*, and must be anticipated and provided for accordingly.

PUMPING AND DRAINAGE.

An efficient, practical and reliable system of pumping and drainage *shall* be adopted at the outset, and every part of the work shall be kept free and clear of water by training the drainage to properly located sumps, the pumping system being ample in power and capacity to keep all parts of the work sufficiently dry to enable the miners and masons to prosecute their part of the work in a reliable and satisfactory manner. Especial pains *shall* be taken to protect all *fresh* work from the effects of running water, and from injury resulting from the passage of man or animals, should the latter be used during the progress of the work. Any system of drainage which fails to fulfil all the conditions embodied herein, in a practical manner, will be rejected, and shall be modified or changed to such extent as the Chief Engineer shall direct.

PRECAUTIONS AGAINST ACCIDENTS.

A proper system of protection against accidents *shall* be inaugurated by the Contractors, coupled with such precautions as shall be deemed necessary to insure the safety of the work while in progress or of the men engaged in its prosecution. These conditions are *imperative*, and the Contractors will be held strictly responsible for *all claims* that may arise from damages to persons or property, following neglect or violation of these plain conditions.

GENERAL REQUIREMENTS.

The liberal use of mortar in all parts of the work *shall* be the *rule*, and not—as is too often the case—the exception.

The entire work *shall* be thoroughly cleansed out prior to final inspection and acceptance.

The work *shall* at all times be open and accessible to the engineering staff, and such reasonable assistance and needed facilities as they may require in the proper prosecution of their labors, *shall* be cheerfully accorded them by the Contractors and their employes.

The Contractors *shall* employ none but competent, sober, and skillful men, and, whenever requested so to do by the Chief Engineer—they *shall* at once discharge any employe who fails in the faithful performance of his duties, or

who neglects to accord prompt and cheerful obedience to practical and decently worded instructions.

All tools and machinery necessary to the safe and proper execution of the work, and all materials and labor required in its thorough construction—entire and perfect in every respect—*shall* be furnished by the Contractors, who *shall* likewise be responsible for its safety and protection until final acceptance by the Chief Engineer.

The Contractors *shall* furnish all stakes needed by the Engineering Staff, and such manual labor or other assistance as may be required for their location and subsequent protection.

No material *shall* be used anywhere in the permanent construction, until the same *shall* have been examined and approved by the Chief Engineer, or by Inspectors acting under his orders; and all imperfect work or defective materials which may be discovered in the permanent construction—*shall*—upon the request of the Chief Engineer—be instantly removed, and the same reconstructed and replaced in a proper and satisfactory manner at the expense of the Contractors.

Whenever the word Engineer is used herein, it shall be understood as meaning the Chief Engineer of the Corporation; and, in a similar manner, the word Contractor or Contractors, shall be understood as meaning an individual or a firm—or any member of such firm, who may have contracted and engaged to execute the work described and defined herein.

The intent and aim of these specifications is to describe the character of the work—the methods to be followed in its execution, and the quality of the materials to be used in its construction in as plain and practical a manner as possible, and the parties contracting to do the work shall honestly conform to all the requirements embodied herein for their guidance and information.

On or about the first of every month approximate estimates will be made by the Chief Engineer for the amount of work actually done during the previous month—and vouchers for the same will be immediately issued to the Contractors, less ten (10) per cent., which will be deducted and retained until the final completion and acceptance of the work, which latter point shall be regarded as reached, when the Chief Engineer shall have made and issued his *certificate of final inspection*.

The Chief Engineer shall decide all questions that may arise as to the correct interpretation of these Specifications, or as regards the proper execution of the work, and his decisions shall be final and conclusive, unless they be absolutely wanting in every essential of justice and equity.

G. HOWARD-ELLERS,

CHICAGO, 1st October, 1885. *Chief Engineer.*

JEFFERSON WATER WORKS---1885.

SPECIFICATIONS,

describing the manner in which it is proposed to construct a brick conduit, and gate chamber with pump well connection, and defining the character and quality of the materials to be used in the execution of the work.

GENERAL DESCRIPTION AND LOCATION.

The work is to be executed in accordance with these specifications embraces the construction of a brick conduit .... feet in diameter, located in ...., from .... to .... a distance of about .... feet; and a gate chamber and pump well connection, located within the grounds of the Pumping Station, situated on .... Avenue, west of its intersection with .... Avenue, in the Town of Jefferson. In general terms it may be said the entire work is to be circular in section, the finished dimensions being—for the conduit—a diameter of .... feet; for the gate chamber, a diameter of eight feet, and for the pump well connection a diameter of .... feet; to be executed throughout in first-class brick masonry, carefully laid up in hydraulic cement mortar, and in every respect to be constructed and finished in a thorough and workmanlike manner, and in strict compliance with such plans as may be furnished by the Chief Engineer, and such instructions as he shall issue during the progress of the work—in person—or through his properly constituted representatives. At several points on the line of this proposed work the conduit will pass beneath the tracks of the Chicago and Evanston—the Chicago and North Western—and the Chicago, Milwaukee and St. Paul Rail Roads—and hence—the practical protection of the tracks in accordance with the views of the respective companies will undoubtedly entail additional expense—inseparable from all such work, which the contractors must anticipate as legitimate, and which they must provide for accordingly.

GRADES.

The conduit *shall* be constructed on a grade which descends from the land shaft in the lake shore, to the gate chamber within the grounds of the Pumping Station, at the rate of five hundredths (0.05) of a foot per one hundred (100) feet; being equal to a grade of two feet and sixty-four hundredths of a foot (2.64) per mile.

PUMPING AND DRAINAGE,

An efficient, practical and every way reliable system of drainage *shall* be devised and adopted at the commencement of active operations, and all parts of the

work *shall* be kept sufficiently dry to enable the workmen to discharge the various duties assigned them in a thoroughly reliable and workmanlike manner. The pumping plant shall be ample in power and capacity to meet all emergencies, and any plan which fails to comply with these requirements in a practical manner, will be rejected, and *shall* be changed to such an extent as the Chief Engineer shall direct.

EXCAVATION AND CONSTRUCTION.

The excavation *shall* be commenced at such points as the Chief Engineer shall direct; and it *shall* be vigorously prosecuted upon such lines and levels as shall be given to the contractors—daily—by the resident engineers in personal charge of the work. The tools and appliances *shall* be of such a character as *shall* render certain the accuracy and rapid progress of the work in hand; and the dimensions and shape of the excavated section, and the manner of prosecuting the work, shall be such as to guarantee the absolute safety of the conduit while in progress, and its stability and standard character when finished. All surplus material which may remain on the line of the work after its completion, shall be removed at the expense of the contractors, or as may otherwise be directed by the Chief Engineer, so that the roadway beneath which the conduit has been constructed, shall be left in the same general condition in which it was found prior to commencing work thereunder. Should rock be encountered, the work shall be prosecuted, and the full section excavated, with such tools and appliances, and with such explosive compounds and weight of charges, as the Chief Engineer only shall direct; and all inequalities in such rock sections *shall* be filled and carefully shaped up to the proper line and levels with concrete and mortar, made in such proportions and otherwise used in such manner as appears elsewhere defined and directed herein. The elevation of the grade line of the conduit, where it joins the land shaft in the lake shore *shall* be .... feet below the general datum plane to which all levels *shall* be referred, and similarly its elevation at the point where its grade line joins the gate chamber within the grounds of the Pumping Station shall be .... feet below the same datum plane. The walls of the conduit *shall* be composed of two (2) rings of brick masonry, except for a distance of about thirty (30) feet from the lake shore shaft and gate chamber, where an additional ring shall be used for the purpose of insuring increased stability; and likewise at such other points, where, in the judgment of the Chief Engineer, solely, the safety and durability of the conduit shall require an additional ring or rings for the same or similar purposes. The inverts *shall* be accurately trimmed out and worked into proper form with standard templets, the surface covered with a thick coating of mortar into which the bricks forming the exterior ring *shall* be imbedded at one operation—laid fair and true by line—generally as stretchers, and always breaking joints with the bricks in the adjoining courses. The arch *shall* be laid up on strong centres in a similar manner, and the centres kept in place until the mortar has taken a permanent set. All cavities around or in the rear of the brick-work shall be thoroughly filled with stiff mortar, or with concrete, as the Chief Engineer shall direct. The thickness of all mortar joints, as well between the bricks as between the rings, *shall* be half (½) inch, and they *shall* be struck and finished smooth and

uniform everywhere, and all surplus mortar adhering to the face of the brick-work shall be removed so that the finished masonry shall be left in a clean and workmanlike condition throughout.

MASONRY.

The character and quality of the bricks that shall be used in the masonry throughout are hereinafter specified. Prior to being placed in the work, all bricks shall be wet to the point of *absolute saturation* with clean water—by immersion entire. In the work—they shall generally be laid as stretchers—fair and true to line, and so placed as to break joints—mid-length—with all bricks in adjacent courses. In the mortar beds—they shall be pressed into their proper positions by one operation for each brick, the object being to flush out all surplus mortar, thereby allowing the mortar joints to remain perfectly filled, and the bricks to be entirely imbedded, with joints on all sides which shall not exceed half (½) an inch in thickness,—*as a rule*—that shall be standard for the work throughout. The *un*workmanlike practice of "slushing" or working the mortar into the joints after the bricks are in place, is *absolutely prohibited*. As the brick-work progresses, it shall *not* be raked back in courses, but at all points where joints are to be made, its temporary ends shall be left "toothed," for the purpose of facilitating the continuity and allignment.

BRICKS.

For use in this work, the harder and denser varieties shall be given the preference. They shall be the best quality, clear ringing, sound and smooth, uniformly burned, and free from lime pebbles and other stones, regular in shape and of standard dimensions. They *shall* be subjected to thorough inspection, when all bricks failing to meet the requirements of these specifications, and all bats *shall* be culled out and placed in a pile by themselves, and their further use limited to concrete, or similar purposes as the Chief Engineer shall direct or sanction.

CEMENT.

The hydraulic cement which *shall* be used—exclusively—in this work, is that manufactured at and near Utica, La Salle County, Illinois, and known in the market as the "James Clark" and "Black Ball" brands. It *shall* be fresh made and ground to such a degree of fineness that eighty (80) per cent. of the powder shall pass through a sieve having thirty-six hundred (3600) meshes to the square inch. If tested for setting qualities and for strength, promiscuous samples *shall* be mixed, neat, with clean water, and moulded into test pieces, which latter *shall* be allowed to stand—undisturbed—for six (6) hours in air, and then be immersed in water for forty-eight (48) hours, at the expiration of which period they *shall* be placed in the testing machine and subjected to a tensile strain of fifty (50) pounds to the square inch, failure to sustain which *shall* be regarded as a sufficient reason for instituting a thorough series of experimental tests, upon the average results of which *shall* depend the acceptance or rejection of the entire lot from which the samples were taken.

SAND.

All sand used *shall* be free from loam, clean, sharp, silicious, and as reasonably coarse as can be obtained in this locality—and—if deemed necessary by the Chief Engineer, it *shall* be screened and washed.

MORTAR—GROUT—CONCRETE.

All mortar *shall* be composed of equal volumes of cement powder and sand—"one to one"—by measure; thoroughly mixed in a dry state, and then brought to proper consistency with clean water, and *always* fresh made for the work in hand: It *shall be used immediately after being mixed*, and not allowed to remain on the *mortar boards* until it has *set*, and then be broken down, remixed or "retempered," so called.

Grout—if used at all—*shall* be composed of neat cement powder and clean water, mixed to such consistency with an excess of water, as *shall* enable it to thoroughly permeate and reach the most distant parts of the work wherein its use *shall* be found obligatory.

Concrete—shall be composed of one part cement powder, two parts sand, and three parts crushed stone, broken bricks or quarry chips, whose dimensions *shall* not exceed one inch and a half in any direction. The proportions of cement powder, sand and stone shall be ascertained and used by measure—the mortar made first as hereinbefore specified—the stone, previously cleansed and sprinkled, shall then be added, and the mass, thoroughly incorporated, shall then be immediately deposited in place in layers not over six (6) inches deep or thick, at a time, and tamped until the water of admixture is flushed to the surface.

GENERAL REQUIREMENTS.

In the absence of the Contractors, all orders from the Chief Engineer—or from the Resident Engineers, *shall* be received and promptly executed by the foremen, or by such other representatives of the Contractors who may be present and in charge of the work.

The liberal use of mortar in all parts of the work *shall be the rule*, and not—as is too often the case—the exception.

All fresh work shall be carefully protected from every species of disturbance until the mortar shall have permanently set in place.

When finished, every part of the work embraced *herein* shall be thoroughly cleaned out prior to its final inspection by the Chief Engineer.

All parts of the work, shall at all hours, be accesible to the engineering staff, and such reasonable assistance and needed facilities as they may require while in the discharge of their official duties, shall always be cheerfully accorded them by the Contractors and any or all of their employes.

None but skilful, sober and experienced men shall be employed in the work, and, whenever requested so to do by the Chief Engineer, the Contractors shall at once discharge all drunken, incompetent or disorderly individuals, or any employe who fails in the honest performance of his duties, or who neglects or refuses to accord prompt and cheerful obedience to proper instructions. *And all parties so discharged shall not again be employed on any part of the work.*

The Contractors shall furnish all stakes need by the engineering staff, and likewise such manual assistance as may be required to locate and place such stakes, and to efficiently protect them so long as their undisturbed condition is essential to the proper prosecution of the work.

All tools and machinery necessay to the safe and proper execution of the work, and all materials and labor required in its thorough construction—entire and perfect in every respect—shall be furnished by the Contractors, who shall likewise be responsible for its safety and protection until final inspection and acceptance by the Chief Engineer.

No material shall be used anywhere in the permanent construction, until the same shall have been examined and approved by the Chief Engineer, or by Inspectors acting under his orders; and all imperfect work or defective materials which may be discovered in the permanent construction—shall—upon the order of the Chief Engineer—be instantly removed, and the same reconstructed and replaced in a proper and satisfactory manner at the expense of the Contractors.

Whenever the word Engineer is used herein, it shall be understood as meaning the Chief Engineer of the Corporation, and, in a similar manner, the word Contractor or Contractors, shall be understood as meaning an individual or a firm—or any member of such firm, who have contracted to execute the work described and defined herein.

The intent and aim of these specifications is to describe the charactor of the work—the methods to be followed in its execution, and the quality of the materials to be used in its construction in as plain and practical a manner as possible, and the parties contracting to do the work shall honestly conform to all the requirements embodied herein for their guidance and information.

On or about the first of every month approximate estimates will be made by the Chief Engineer for the amount of work actually done during the previous month—and vouchers for the same will be immediately issued to the Contractors, less (10) per cent, which shall be deducted and retained until the final completion and acceptance of the work, which latter point shall be regarded as reached, when the Chief Engineer shall have made and issued his certificate of final inspection and acceptance.

The Chief Engineer shall decide all questions that may arise as to the correct interpretation of these Specifications, or as regards the proper execution of the work, and his decisions shall be final and conclusive, unless they be glaringly deficient in every essential of justice and equity.

G. HOWARD-ELLERS.

CHICAGO, 1st October, 1885. *Chief Engineer.*

Form of Special Notice which should be attached to all Proposals and Specifications, etc.

JEFFERSON WATER WORKS—1885-6.

SPECIAL NOTICE.

Contractors are particularly requested to carefully read the specifications attached hereto, and likewise to examine for themselves the location of the proposed work, so that no misconception may arise as to the precise character of the work to be executed. The measurements and quantities given herein are approximate only, and bidders are notified that the Board of Trustees reserve the right to increase or diminish same, and that no allowance will be made in case of their increase for any sum above the price bid, nor in case of decrease, for any real or supposed damage or loss of profit occasioned by such diminution; but the time specified herein for the full completion of the work will be proportionally increased or diminished, in the discretion of the undersigned. The prices stated by bidders herein will include all labor, as well as the furnishing of all materials .... and it will also include all "grubbing and clearing,"—all "sheeting and shoring," and all "bailing and draining," and, in general all expense incurred by or in consequence of an absolute compliance with each and every one of the requirements of the annexed specifications, and for the thorough and faithful completion of the work, in the manner therein specified. No bid will be accepted from, or contract awarded to, any party who is in arrears to the Town of Jefferson, upon debt or contract, or who is a defaulter, as surety or otherwise, upon any obligation to said Town. The right to determine the times and places for commencing and prosecuting the work referred to herein, is expressly reserved, and bidders are informed, that, under no circumstances, will any deviation from these specifications be allowed or recognized, without the written permission of the undersigned, whose interpretation thereof will be final and conclusive.

Companies or firms tendering, must state herein the individual names and places of residence of the persons comprising such company or firm, as well as the names of all parties interested with them therein. All proposals *must be made upon the regular printed blanks* furnished by the undersigned, and *all tenders will be rejected for informality which are not made thereon*, and which are not—in all other respects,—in strict conformity with this notice. The Board of Trustees expressly reserve the right to reject any or all bids which may be deemed prejudicial to the public interests.

G. HOWARD-ELLERS,
Chief Engineer.

BLANK FORM OF PROPOSAL TO LAY WATER PIPE.

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To the—

BOARD OF TRUSTEES,

of JEFFERSON, ILL.,

GENTLEMEN :

The undersigned having carefully read the specifications attached hereto, and having gone over and personally examined the streets and avenues in which it is proposed to lay said .... cast iron water main, hereby propose to furnish all the materials, except straight pipe, special castings, water gates and gate boxes and covers, and to do all the work of any and every description required to put said pipe and appurtenances *in place*, ready for public use, for the prices and at the rates set forth below, viz:

For the .... water main, together with all special castings and water gates, put in place only, &c., ... dollars and .... cents per linear foot.

These prices to include all "grubbing and clearing," all "sheeting and shoring," all "bailing and draining," all excavation of solid or loose rock, and all bedding and back-filling of sand in rock trenches, and to be in full and absolute compensation for any and everything required to finish the work in strict accordance with the annexed specifications in every respect, and in compliance with the foregoing "Special Notice" attached hereto. The above proposal is made under the express conditions, and the undersigned hereby expressly agree, that, in case this tender is accepted by the Town of Jefferson, and the undersigned should *fail* or *neglect* to promptly enter into such contract with said Town for the full and complete execution of this work as shall be required by the Board of Trustees, and within two (2) days following the receipt of notice of acceptance of this tender, then the sum of one thousand dollars deposited herewith, shall be forfeited to the Corporation, and all claim thereto is hereby relinquished.

....

Residence ....

....

Residence ....

JEFFERSON WATER WORKS.--1885.

SPECIFICATIONS,

describing the manner in which it is propsed to handle and put into permanent place, a cast iron water main, and defining the quantity and quality of the materials to be used in the execution of the work.

GENERAL DESCRIPTION AND LOCATION.

The work to be executed in accordance with these specifications embraces the handling and laying of about .... linear feet of a cast iron water main, ... inches interior diameter, in lengths of about 12 feet 4 inches each, and weighing about .... lbs. per linear foot, or about .... lbs. per length ; together with some .... pieces of special castings in the shape of "quarter bends," "angles," "hydrant tees," and crosses," and likewise .... water gates, the latter to be placed in boxes with manhole covers; all of which will be furnished by the Town, and will be distributed along the line of the proposed work convenient for final handling and disposition. The location as proposed

is in ____

from ____

to ____

and the work shall be prosecuted in such a manner as to present the least possible obstruction to roadway traffic, or to the legitimate use of the intersecting streets and sidewalks.

GRUBBING AND CLEARING.

All trees, stumps, logs or bushes shall be removed from the line of the trench and disposited in such position sufficiently remote therefrom as to insure their permanent separation from the back-filling.

SHEETING AND SHORING.

Should any portion of the material through which the trench may be excavated prove deficient in stability, then the proper position of the sides and the condition of the trench shall be maintained by a thorough system of sheeting, shoring and bracing.

BAILING AND DRAINING.

The trench shall be kept clear of water by training the drainage to properly located sumps, and the pumping system shall be ample in power and capacity to keep the trench sufficiently dry to enable the "jointers," and "caulkers," to execute their part of the work in a thorough and reliable manner. Any system of drainage which fails to fulfill these conditions in a practical manner, will be rejected, and shall be changed to such an extent as may be directed by the Chief Engineer

EXCAVATION AND BACK-FILLING.

The trench shall be excavated in strict conformity with the lines and levels given by the Resident or Assistant Engineers *and in no other way*, and it shall be of full and sufficient width to enable the workmen to handle the pipe and their tools with ease and facility, and generally to such depth, that the upper side of the main, when in permanent position, shall *in no place be less than five* (5) *feet beneath* the *surrounding* or *natural surface* of the *ground.* The cross-trenches for the bell ends of the pipe shall be of sufficient width and depth to enable the workmen to properly insert and pack the rope-yarn, and to pour the lead, and caulk the joints perfectly throughout. The back-filling shall always closely follow the finished pipe and all surplus excavation shall be dressed up over the center of the trench in a shapely and workmanlike manner. Before commencing the excavation, all materials composing the cross-walks, the roadway paving, or other similar improvements, shall be carefully removed and piled where they will be out of the way of the street traffic, and beyond the possibility of admixture with the material taken from out the trenches; and when the main is finished in place, the back-filling shall commence at once, and, as it progresses, *it shall be thoroughly tamped* to such an extent as to render subsequent settlement of the surface practically impossible; and the roadway shall then be thoroughly cleaned up, the cross-walks and the MacAdam or paving re-placed, and generally the surface shall be left in the same condition in which it was found prior to commencing work thereon. The same requirements shall apply to the various drainage ditches crossing the proposed line, and through which it will be necessary to carry the pipe, and the general condition in which they shall be found—shall—in every instance, be practically restored.

PIPE LAYING.

Each length of pipe shall be carefully placed in its proper position in the bottom of the trench previously prepared for its reception, the interior shall be thoroughly cleaned out, the bead ends inserted and sent home concentrically into the bells and the allignment adjusted. The rope-yarn used for the gaskets shall be of the very best quality, and, after being wound into place, it shall be packed and driven to a uniform bearing against the bead at the back of the joint. The *quantity of rope-yarn used* shall be.................................*pound in each joint.* The lead used for the same purpose shall likewise be of the *very best quality* of American pig, soft and free from scoria, and, when melted and poured into place, it shall be set up uniformly and the joints shall be thoroughly and carefully caulked at all points. During the process of melting the lead, preparatory to pouring, it shall be skillfully handled so as to prevent either burning or over-heating. *Each joint shall contain not less than*...*pounds of lead*, which shall always be poured into place from *one full ladle and at a single operation.* None but known and experienced caulkers will be allowed to do this part of the work. The exceedingly reprehensible practice of joining permanently several lengths of pipe on the surface, and then rolling and lowering the same—practically as one piece—into the trench, *will not be permitted under any circumstances.* All water gates or stop valves, together with their boxes and covers, shall be properly put in place at such points in the line as the Chief Engineer shall direct—or, through

his Assistants, designate; and all plugs in crosses, tees and reducers *shall* be inserted in the bells and carefully packed and caulked and secured in place.

TIME FOR FINAL COMPLETION.

The entire work shall be finished, ready for final inspection and subsequent pressure test, in..*working days*, which period shall commence on the fifteenth day after the contract has been approved by the Board of Trustees, and the official signature of the President, duly attested by the Clerk, has been affixed thereto.

PRESSURE TEST.

Upon the completion of the work ready for public use, the entire line *shall* be subjected to a hydrostatic pressure of 150 pounds per square inch, which said pressure shall be maintained at all points for a period not less than five (5) hours, as the Chief Engineer shall decide and elect.

PRECAUTIONS AGAINST ACCIDENTS.

All unfinished parts of the work *shall* be surrounded and efficiently protected at all hours by ample and sufficient barriers, on which red signal lights *shall* be placed and maintained at night-time, together with such additional precautions as *shall* be deemed necessary by the Chief Engineer for the absolute protection of the traveling public. These conditions are imperative, and the Contractor will be held strictly responsible for *all claims* that may arise from damages to persons or property following neglect or violation of these plain requirements.

PAYMENTS.

On or about the first of every month during the progress of the work, approximate estimates will be made by the Engineer of the amount of work actually finished in place during the previous month, and vouchers for the same will be issued to the Contractor or Contractors, less ten (10) per cent. which will be deducted therefrom, and which will be retained until the final completion and acceptance of the work, which latter point will be regarded as reached, when the Chief Engineer shall have made and issued his certificate of final inspection and acceptance of the work.

GENERAL REQUIREMENTS.

In the absence of the Contractor, all orders from the Chief Engineer *shall* be received and promptly executed by the foreman, or such other representative of the Contractor who may be present and in charge of the work.

None but skillful, sober and experienced men *shall* be employed in the work, and, whenever requested so to do by the Chief Engineer, the Contractor *shall* at once discharge all drunken, incompetent or disorderly individuals, or any employe who fails in the honest performance of his duties, or who neglects or refuses to accord prompt and cheerful obedience to proper instructions. *And all parties so discharged shall not again be employed on any part of the work.*

The Contractor *shall* furnish all stakes needed by the engineering staff and such

manual assistance as may be required for the location of said stakes and their subsequent protection.

All tools and machinery necessary for the safe and proper execution of the work, and all materials and labor required in its thorough construction, *entire and perfect in every respect*, shall be furnished by the Contractor, who *shall* also be responsible for its safety and protection until final test and acceptance by the Chief Engineer.

The work *shall* at all times be accessible to the engineering staff, and such reasonable assistance and needed facilities as they may require in the proper prosecution of their labors, *shall* be cheerfully accorded them by the contractor and all of his employes. No material *shall* be used in the permanent construction, until the same *shall* have been examined and approved by the Chief Engineer, and all imperfect work or defective materials which may be discovered in the permanent construction—*shall*— upon the order of the Chief Engineer—be instantly removed, and the same re-constructed and replaced in a proper and satisfactory manner, at the sole expense of the contractor.

The Chief Engineer shall decide all questions that may arise as to the correct interpretation of these specifications, or as regards the proper execution of the work, and his decision shall be final and conclusive, unless they be absolutely lacking in every essential of justice and equity.

Whenever the words Chief Engineer are used herein, they shall be understood as meaning the Chief Engineer to the Corporation—and in like manner, the word Contractor, or Contractors, shall be understood as meaning an individual or a firm—or any member of such firm, who may have contracted to execute the work described and defined herein.

The intent and aim of these specifications is to describe the character of the work—the methods to be followed in its execution, and the quantity and quality of the materials to be used in its construction, in as plain and practical a manner as possible, and the parties contracting to execute the work, shall honestly conform to all the requirements embodied herein for their guidance and information.

G. HOWARD-ELLERS,

CHICAGO, 1st October, 1885. *Chief Engineer.*

JEFFERSON WATER WORKS--1885.

SPECIFICATIONS,

describing and defining the general character and structural details of a pumping outfit, to consist of two pumping engines and three boilers, to be used in connection with a proposed system of water supply for the Town of Jefferson, Ill.

FOUNDATIONS.

The foundations—one for each engine—*shall* be composed of brick and stone, in accordance with drawings to be exhibited by the parties furnishing the machinery. The bricks shall be of the best quality, hard and uniformly burned, clear ringing, sound and smooth. The face of the work shall be finished with selected front bricks of a bright red uniform color. Prior to being laid up in the work, *every brick shall be wet to the point of absolute saturation by immersion entire* in clean water, where they *shall remain not less than one hour before being used.* The mortar shall be composed of Utica cement, of the "James Clark" brand, *fresh ground and packed*, mixed *neat* with clean water and *used immediately after admixture.* The caps of the piers on which the pumps and steam cylinders rest, and the floors of the pits in which the air pumps and condensers are placed, shall be composed of single blocks of blue stone or granite, finely dressed, not less than ten (10) inches thick, and of such linear dimensions as the exhibited plans and drawings shall require. The brick-work composing each foundation shall rest on a solid bed of concrete, four (4) feet thick, and extending one (1) foot beyond the same on the sides and rear ends, the front ends abutting on the back of the rear wall of the pump well, but entirely disconnected therewith, for the purpose of preventing any possible distortion due to unequal settlement. The stone caps shall be drilled, and the brick-work provided with such holes and recesses for the anchor bolts, whose positions and dimensions shall be shown and defined on the plans furnished by the parties to whom the contract may be awarded for the pumping machinery.

ENGINES.

The engines *shall* be of the "Duplex" type, with a combined capacity equal to the delivery of four million gallons of water per diem, against an extreme pressure of one hundred and fifty pounds per square inch, and an ordinary service pressure of sixty pounds; with a maximum boiler pressure limited to ninety pounds per square inch. Each engine shall consist of two horizontal double acting pumps, with central exterior stuffing boxes, and with plungers not less than fourteen inches in diameter, set side by side on the same frame; each pump actuated directly by a horizontal, direct acting, compound, high-pressure con-

densing engine, with steam jacketed cylinders of not less than sixteen and twenty-eight inches diameters respectively, the strokes of the engines and pumps being not less than thirty inches. The steam jacketing system shall be provided with suitable steam traps and connections for removing the water of condensation, and delivering the same into the hot well. The engines shall be constructed and arranged in pairs—each pair, on a single frame, shall be capable of working together with the duplex principle of valve movement, or, by disconnecting the duplex gearing, each individual pump, actuated by the particular portion of the steam machinery to which it is attached, shall be capable of temporary operation as an independent pumping machine by itself. The air pumps shall be single acting, actuated from the ends of bell crank levers, whose longer arms are attached to the main cross-heads by links or short connecting rods; or, an independent condensing apparatus may be substituted, by which the power otherwise absorbed in actuating the air pumps, would be more profitably expended in forcing water into the general system of distribution. All piston rods, valve stems, links, connecting rods, air-pump rods, and generally all parts subjected to continuous tensile strains, or to alternating strains of extension and compression, shall be of *steel* of standard quality; and all steam cylinders, pump cylinders, pump plungers, steam chests, and air pump cylinders, shall be of fine, close-grained cast iron, as hard as can be conveniently handled in their general fabrication. All bearings shall be lined with the best composition metal, or with an alloy of copper and tin of approved proportions and recognized utility. All steam cylinders, steam chests, steam pipes, and generally all parts requiring adequate protection against loss of heat by radiation, shall be covered with a plastic composition of asbestos, or with a similar compound of acknowledged utility; over which shall be placed a double thickness of the best hair felting, both of which shall—in turn—be covered or surrounded with a lagging composed of narrow matched strips of seasoned black walnut, oiled and dead polished, and substantially secured in place with polished brass bands, fastened with hemi-spherical headed brass screws. An independent steam pumping machine, of ample power and capacity, shall be furnished and fixed in the boiler room, with proper connections with the hot well and boilers for feeding purposes, and likewise with such additional connections with the cold water supply through which the boilers can be filled or fed, or the main pump cylinders charged, whenever either of the latter may be found necessary.

A standard indicator shall be furnished, and proper provision made for connecting it with the steam and pump cylinders whenever desired.

The duty required of these engines—and which they shall develop on trial—shall be the elevation of seventy million pounds of water one foot high, with a consumption of one hundred pounds of good merchantable coal, from which there shall be no deductions allowed for ashes, clinkers or waste. The duration of the trial for this duty shall not be for a less period than *seventy-two consecutive hours*.

There shall also be furnished and put in place a complete set of standard steam, water and vacuum gauges, and a set of counters on the engines, together with whatever shall be required in the way of sight feed lubricators, steam traps, drain pipes, drip pans, duplicate valves, wrenches, spanners and portable

swinging cranes, and generally everything that may be required in and around the machinery necessary to constitute it a complete, practical and reliable pumping plant for a direct system of water supply. The character and quality of the materials used—the theory upon which the various parts are proportioned, and the workmanship displayed, shall be such as is recognized as the best of its kind and class by the standard practice of the day.

BOILERS.

Note.—The specifications which follow for the Babcock and Wilcox water tube boilers, are not original with the undersigned, but are those furnished by the Babcock and Wilcox company, and hence, to that extent, are an expression of the practice of one of the most extensive concerns engaged in the construction of steam generating plant in the world. I have supplemented these with a set of specifications covering a battery of cylinderical return tubular boilers, although, as I have already stated in the body of my report, I unhesitatingly recommend the B. and W. water tube boiler in preference to all others on the score of economy in the consumption of fuel, general safety and unquestioned durability.

G. H.-E.

NUMBER AND ARRANGEMENT.

There shall be three (3) boilers, arranged to be set in one (1) battery.

SECTIONS. HEADERS. JOINTS. CONNECTION.

Each boiler shall be composed of six (6) sections or slabs, each section to be composed of seven (7) best lap welded wrought iron tubes, four (4) inches in diameter, and sixteen (16) feet long, connected at the ends by contiguous, staggered headers, or "up-takes" and "down-takes"; the tubes to be fastened therein by expansion into tapered holes. Each "header" to be provided with hand-holes, placed opposite the end of each tube, of sufficient size to permit the cleaning, removal or renewal of a tube through the same. Each hand-hole provided with a cap fastened with wrought iron bolt and clamp and cap nut. All joints made tight without packing of any kind. The several sections to be connected at each end to a steam and water drum, and at one end with a mud drum, by means of lap-welded wrought iron tubes, four (4) inches in diameter and of suitable length, expanded into bored holes.

DRUMS. MANHOLE.

The steam and water drums to be thirty (30) inches in diameter, and sixteen (16) feet long, made of flange iron, five-sixteenths of an inch thick, the longitudinal seams double rivited. To have a man-hole in front head—two nozzles, one for safety-valve and one for taking off steam, four (4) inches in diameter, with ten (10) inch flange, faced and drilled.

MUD-DRUMS. BLOW-OFF.

The mud-drums, to be of cast iron, eighteen (18) inches diameter and forty-five (45) inches long, with a hand-hole and nozzle for blow-off pipe, two and a half inches diameter.

SUPPORTS.

The battery is to be supported by wrought iron beams, resting on four wrought iron columns, with cast iron bases properly secured so that the boiler shall be sustained entirely independent of the brick work, and free to expand or contract without affecting the same, and so that the brick work may be removed and replaced, if required, without disturbing the boilers or connections.

VALVES AND FITTINGS.

SAFETY VALVE.

Each boiler to be provided with a "Consolidated Company's Nickel Plated Safety Valve," three (3) inches diameter; set to blow off at ninety (90) pounds.

STEAM GAUGE.

One steam gauge, dial twelve and one-half inches diameter.

WATER GAUGE.

One stand pipe, with large sized glass water gauge, fitted with independent cleaning pipes and valves, and three patent gauge-cocks with lifting handles.

FEED VALVES.

One check valve, one and one-half inches diameter, for feed.
One stop valve, one and one-half inches diameter, for feed.

BLOW-OFF VALVE.

One blow-off valve, two and one-half inches diameter.

CLEANING VALVE.

One stop-valve, three-fourths inch diameter, for cleaning pipe connection.

PIPING.

The necessary pipes and fittings for fixing all the above to the boilers.

FRONT.

The front of cast iron to be of ornamental pattern, containing three fire doors with registers, three double ash pit doors, and large door for access to the ends of the tubes. All parts to be ample in strength, joints fitted.

FIXTURES.

The fixtures for the boilers to consist of a full set of grate bars with bearers, dead plate and girders, flame bridge plates with bolts and special fire brick for lining the flame bridges, bridge wall girders and bars, binders and bolts, six ash

pit and nine cleaning doors for access to the exterior of tubes, and the flues for cleaning, one damper with frame, and the requisite lintels for openings in walls; smoke chamber T's and anchor bolts for front.

Delivered and erected with all piping and valves complete. Boiler to be tested and ready for operation.

TOOLS.

One steel wrench fitting the hand hole nuts, one tube scraper with handle, set of fire tools, consisting of poker, slice bar and hoe, and hose and pipe for blowing dust from exterior of tubes, to be furnished.

TESTING.

The sections and mud-drums to be tested and made tight under a hydraulic pressure of three hundred pounds per square inch, and the steam and water drums to be tested and made tight under a hydraulic pressure of one hundred and fifty pounds per square inch.

QUALITY.

All materials and workmanship to be first class in every particular.

WEIGHT.

Approximate weight one hundred and six thousand (106,000) pounds.

SPACE.

Space occupied to be, including brick work twenty-one and one-half feet long, eighteen and one-half feet wide, and fourteen and one-half feet high (to top of steam opening).

ERECTING.

Full drawings and directions for erecting to be furnished and services of man to do mechanical work, and superintend erection.

BOILERS.

NUMBER AND STYLE OF SETTING.

There shall be three (3) boilers, set side by side, separated by a twenty-eight (28) inch brick wall, faced with fire bricks and enclosing an air space not less than four (4) inches wide, and so arranged in the setting, that the heated products of combustion from the furnaces, after passing under the boilers and returning through the tubes, shall rise in front and then pass to the rear over the tops of the boilers, through the passageways formed by the latter and the fire brick arches, and finally reaching the main flue in the chimney stack through the flue system in the rear of the plant.

The exterior of the settings shall be composed of pressed front bricks of a uniformly deep red color, laid up in hydraulic cement mortar; and the interiors throughout—such as the furnaces, bridge walls, combustion cham-

bers, back arches, partition walls and top arches, shall be lined and finished with Mount Savage fire bricks, laid up in the usual way—as headers and stretchers—in fire clay mortar, and otherwise finished in a substantial and workmanlike manner.

The bridge walls shall be finished on a horizontal line, and the elevation of their crests above the grate bars shall be limited to a height only sufficient to protect the mass of fuel thereon. The furnaces shall be constructed and proportioned to accommodate a grate whose length shall not exceed four (4) feet; and generally, throughout the interiors of the settings, the space enclosed shall be sufficiently liberal to render all surfaces exposed to the direct action of the fire, easily accessible for cleaning, inspection and repairs. Both exterior and partition walls shall enclose air spaces not less than four inches wide; and their allignment and stability shall be preserved and assured by a thorough system of buckstaying, proportioned and put in place in a reliable manner.

GENERAL DESCRIPTION. MATERIALS. FABRICATION.

Each boiler shall be of the horizontal, return tubular type—cylindrical in section—sixty (60) inches in diameter and sixteen (16) feet long—all interior dimensions; with thirty-six (36) tubes, each four (4) inches diameter, arranged in two groups, with a central vertical dividing space not less than eight (8) inches wide in the clear, in the center of the boiler. The tubes shall be arranged in straight rows—both vertically and horizontally, with clear straight spaces between the rows, and with a similar clear space between the exterior line of tubes and the interior sides of the shell never less than four inches at any point, and as much more than this at the lower quarters, and particularly at the bottom, as can conveniently be obtained, without otherwise interfering with the proper arrangement and spacing of the tubes within the areas to which they are practically limited. There shall be two man-holes in each boiler, one in the front head below the tubes, and one in the top as near the rear end as approved practice sanctions; *but no steam domes or mud-drums.* The feed pipes shall be carried through the center of the front heads above the flues, and they shall extend into the interior of the boilers for a length of not less than ten (10) feet. Each boiler shall be provided with two cast iron nozzles, one for the safety valve and one for the steam pipe riser, set in the tops of the boilers as hereinafter specified. Steam shall be taken through a dry pipe placed in each boiler near the top, and otherwise proportioned and secured in place as subsequently defined herein.

The material out of which the shells, heads and tubes of these boilers shall be fabricated, shall be *high class steel* from establishments whose productions have received the stamp of recognition at the hands of the most eminent experts in the current boiler practice of the day. Generally it may be said the steel used shall possess an ultimate resistance to extension of from sixty thousand to sixty-five thousand pounds per square inch, and with an elastic limit fully equal to fifty per centum of its ultimate tensile strength: That a piece of such steel, eight inches long, shall elongate not less than

twenty per centum before rupture, with a reduction in area not less than forty-five per centum; and that it will bend over or turn back on itself dead flat, when cold, or will do the same after being raised to a high temperature and then suddenly plunged into cold water; in neither case, after subjection to such or similar treatment, showing either surface cracks or flaws of the most minute character. Preferably, the tubes shall be from the establishment of Morris, Tasker & Co., or from the National Tube Works. The thickness of the plates composing the shells shall be five-sixteenths of an inch, and the heads half an inch, and every plate shall have the makers name plainly stamped upon its surface, together with the ultimate tensile strength—expressed in pounds per square inch—which it is guaranteed to possess. The shell of each boiler shall be composed of two sheets only, the sheet forming the bottom of the boiler being of sufficient width to locate the two longitudinal seams at least two (2) inches above the upper line of flues, or as much higher as the width of the sheets will permit. All longitudinal or horizontal seams shall be double staggered riveted, and all circumferential or girth seams shall be single riveted; *all rivet holes shall be drilled* and should the holes fail to match when the sheets are assembled, the reamer shall be used to true up the holes, but *not the drift pin under any circumstances;* and all seams shall be caulked in accordance with the best practice and in the most thorough manner throughout.

BRACES.

There shall not be less than eighteen (18) braces in each boiler, nine (9) to each head, each brace to be not less than four (4) feet long, to be made of steel, or of the highest grade of wrought iron—preferably "Ulster" or Burden's Best,"—round—and never less than one (1) square inch net area, and fastened in place with jaws and turned pins of equal strength. The heads shall be stiffened with steel T.s arranged in the most approved manner, and riveted to the heads with seven eighths inch rivets. All rivet holes, and all holes through the T bars for rivets and brace pins *shall be drilled in every instance.*

FLANGES.

All flanges shall be carefully bent to an interior radius of not less than two (2) inches, and the total absence of surface cracks or flaws will be regarded as an index of the care displayed in the execution of this important part of the work, as well as an additional guarantee of the superior quality of the material used.

MAN-HOLES.

Each boiler shall be provided with two (2) elliptical man-holes, each eleven (11) inches by fifteen (15) inches in the clear, one in the front head below the flues, and one in the top of the shell, near the rear end of the boiler. The interior of the shells and heads surrounding these man-hole

openings, shall be re-enforced with elliptical rings, six (6) inches broad and three fourths of an inch (0.75) thick; riveted in place with countersunk rivets finished flush with both interior and exterior surfaces. These rings shall be cut from steel plate, of the same quality as that composing the shells and heads, and they shall be faced off and otherwise finished in the most approved manner, the edges chamfered or trued off and the holes *drilled*. The man-hole plates shall likewise be of the same quality of steel, but of such additional thickness as shall guarantee equal strength with all surrounding parts, and they shall be properly secured in place with wrought iron yokes and bolts of the most approved proportions.

RIVETS.

No rivets of a less diameter than three-fourths (0.75) of an inch shall be used, and they shall be of standard quality and make—Burden's best—for instance, and put in place with a pitch of not less than two (2) inches.

NOZZLES.

Each boiler shall have two (2) bell shaped nozzles, of soft tough cast iron, double flanged, the lower flange, which fits on the shell of the boiler, shall have an extreme diameter of not less than twelve (12) inches. The inside diameter of each nozzle at the top shall be five (5) inches in the clear, and at the bottom somewhat more in keeping with the bell-like shape specified, and both flanges shall be drilled for the requisite number of rivets and bolts, and otherwise adjusted and fitted in the most approved manner.

SAFETY VALVES.

Each boiler shall be provided with a nickel seated safety valve of the most approved style, with a clean diameter of five (5) inches, and furnished with a properly proportioned lever and weight adjusted and set to counter-balance a pressure in the boilers equal to ninety pounds per square inch.

FUSIBLE PLUGS.

Each boiler shall be provided with a fusible plug, set in the rear head, at a point not less than four (4) inches above a line drawn through the center of the upper row of tubes.

DRY PIPES.

Each boiler shall be provided with a dry pipe made of steel—of the same general character as that composing the body of the boilers—not less than eight (8) inches diameter, and of proper length, and fixed in the interior of each boiler near its top. The upper surfaces of these dry pipes shall be drilled with a sufficient number of holes, correctly spaced and of proper diameter, whose aggregated area shall not be less, than the area of the dry pipe, multiplied by two.

FRONTS.

Each boiler shall be provided with an extra heavy ornamented cast iron full fire front, with double flue doors swinging on substantial hinges to the right and left, and exposing the entire front head of the boiler when opened —set at a proper distance in front of the boiler and with proper connection therewith. There shall also be two furnace doors and two ash pit doors—set separately, and opening in opposite directions, and with registers in each door. All parts shall be properly proportioned and of ample strength, and all joints shall be made in a thorough and substantial manner.

FURNACE AND GRATE BARS.

The furnace shall be four (4) feet long, and not over five (5) feet wide, and grate bars of approved pattern shall be furnished with each boiler and put in place ready for use. The surface of the grates—when in place—shall be thirty-six (36) inches below the bottom of the boilers.

BLOW-OFF.

Each boiler shall be provided with a blow-off pipe, not less than two (2) inches clean diameter, and at the point where connection is made with the shell, the latter shall be re-enforced with a steel plate half an inch thick and not less than ten (10) inches diameter, secured in place with countersunk rivets finished flush on the interior face, and then tapped or otherwise prepared to receive the pipe, or a nozzle may be substituted, and the blow-off pipe connected thereto.

DAMPER.

Each boiler shall be provided with a damper properly set in place with frame and gearing, and so arranged as to be easily handled from the fire fronts. The area of the damper shall be fully equal to the aggregated area of all the tubes whose action it is intended to control.

VALVES, FITTINGS, FIXTURES, TOOLS.

There shall be provided and furnished with each boiler, and properly attached, connected or put in place :

One Ashcroft steam gauge with a twelve-inch dial.

One Water gauge with inch connecting pipes, best Scotch glass tube, sixteen inches long and three-fourths of an inch diameter, with independent cleaning pipes and valves, and with three seven-eighths inch cocks.

One Blow-off valve, two inches clean diameter.

One Stop valve, one and a half inches in diameter.

One Check valve, one and a half inches in diameter.

One five-inch Globe valve.

One Soot door and frame, nineteen inches by twenty-five inches, with arched top.

One set of Skeleton arch-plates—together with the main steam pipe, and connecting pipes thereinto from each boiler—of steel, or wrought-iron of standard quality, *exclusively;* feed pipes and connections; dead plates; mouth pieces; bearing bars; wall plates; rollers; anchor bolts and nuts;lugs; buckstays; supports; and two sets of Firing tools complete, consisting of coal scoops, pokers, tube cleaners, slice bars, hoes, etc., and everything requisite and necessary to make the plant a perfect one in every respect—delivered and put in place—with all connections made on the same steam line, ready for use, and in every way according to the precepts of the most advanced boiler practice of the day.

It is the intention of these Specifications to describe—in a plain, practical manner—the character of the machinery and boilers to be furnished, the quality of materials to be used and the class of workmanship to be exhibited in their fabrication, and the parties to whom the contract shall be awarded, shall conform —in a business-like manner—to all the conditions embodied herein for the guidance and information of all concerned.

G. HOWARD-ELLERS,

CHICAGO, 1st October, 1885. *Chief Engineer, &c.*